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ARTICLES

INVESTIGATIONS OF A RECURRENT FLIGHT PATTERN OF FLOOD WATER *AEDES* MOSQUITOES IN KERN COUNTY, CALIFORNIA [1]

GORDON F. SMITH, Entomologist; A. F. GEIB, Manager; AND
LEWIS W. ISAAK,[2] Entomologist; Kern Mosquito Abatement District

For a considerable number of years the northern portion of the urban area of Bakersfield, California has been invaded periodically during the summer months by flood water *Aedes* mosquitoes from unknown sources. The only early reference to this problem in the district files is a letter dated in 1938 to the University of California. This letter described periodic flights of *Aedes* mosquitoes into the Bakersfield area and requested aid in determining their origin. Limited investigations were conducted by the University without results.

During the period 1946 through 1952 these flights became progressively heavier, reaching a point where the residents of the affected area were subjected to very heavy biting rates during the daylight hours and were unable to carry on their customary outside activities with any degree of comfort. In August and September of 1949, flights moved into the affected area in much heavier numbers than had been previously experienced. Service requests exceeded 100 per day during the peak periods.

Prior to this time no concentrated effort had been directed toward locating the source of the invading mosquitoes. By this time it became plainly evident that the situation was not being abated through normal district activities and that flights were originating either at a source as yet unsuspected within the district or coming from outside the district boundary. During the latter part of the 1949 season, intensive special inspections within the district boundaries failed to turn up any possible source. By the end of the 1949 season it was apparent that a special study would be necessary to locate the source of these mosquitoes.

In examining the known facts prior to beginning the study, several things were apparent:

1. The north edge of the urban area of Bakersfield lies eight miles from the nearest district boundary across dry foothills. Although considerable numbers of *Aedes* could be found in the foothills north to and beyond the district line during the flight periods, no source could be found in this area.
2. The invasions followed a rather definite pattern as shown by the rise and fall in numbers of service requests due to *Aedes* mosquitoes over a period of time. They occurred principally during the period from June 1 through September 30.
3. The frequency of the flights increased with the temperature. They were from about 10 to 14 days apart during the cooler part of the summer, and about 5 days apart during the hottest season in August and early September.
4. The flights were characterized by a sudden influx of mosquitoes, reaching an immediate peak and dropping off over a period of several days. The pattern appeared to be that of a frontal movement.

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[1] From the Papers and Proceedings of the 12th Annual Meeting of the American Mosquito Control Association, Beaumont, Texas, February 5–7, 1956.

[2] Presently with the Bureau of Vector Control, California Department of Public Health.

Urban Bakersfield encroaches to the north on a foothill area running roughly east and west. These foothills swing to a north-south direction west of the urban area. The flights struck this foothill area first, and, if intensity was high, gradually filtered into the northern part of the lower areas of the city.

The major species involved was *Aedes nigromaculis* although some *Aedes dorsalis* were captured during the flights. *Aedes nigromaculis* is not a native California species. It was first taken in 1938 in the northeast portion of the state, but has since become the primary flood water *Aedes* associated with irrigated agriculture. Instead of one generation a year in river overflow lands, one generation is produced with each irrigation, in some areas 15 to 20 generations per year, developing in tremendous numbers during the latter part of the season.

It seemed very unlikely that a single source of *Aedes* of sufficient size to produce the numbers of mosquitoes involved in these flights could be present but unknown within the confines of the district. The periodicity of the flights was, however, indicative of an irrigation cycle, so another intensive field search was made in the district to the north and northwest of the city. At the same time, an aerial survey was made of the dry foothill area north of the city for a distance of 30 miles to determine whether or not there were any irrigation operations in that area which might serve as sources of the flights. Both of these searches resulted in negative findings. Poso Creek, a small stream north of the city running through the foothills from east to west, was considered a possible source for a time. *Aedes* adults were found in considerable numbers in the green growth along the stream banks during flight periods. During the summer the water in this stream is entirely derived from oilfield operations and the flow was found to fluctuate considerably. Continued inspection of this stream failed to turn up any *Aedes* larvae or any indication of recent emergences during the flights.

During this early period, attempts were made also to trace back to the source by checking biting rates over a wide area in the valley and foothills. It was found that the heaviest biting rates were in the northern foothill fringe of the city. Second heaviest biting was found in isolated areas of green vegetation in the foothills proper, and the lightest biting was in the irrigated area adjacent to the foothills. This dry foothill area, which would seem to be the last place to expect to find *Aedes* mosquitoes, was found to be much more extensively invaded than had been expected. Rather than being on the margin of the affected area, it now appeared to be the principal area hit by the flights. The mosquitoes were also found in the lower reaches of the Tehachapi Pass to the east as far as Keene, approximately 28 miles southwest of Bakersfield.

In order to check for correlation of *Aedes* mosquito population throughout this area, light traps were established at Woody, approximately 27 miles north, northeast of the city, and at Keene. Body count stations were also established through the foothill area north of Bakersfield. These stations lay in a north-south line, paralleling the east side of the valley and from 8 to 10 miles into the foothills, extending to a point 14 miles north of Bakersfield. These stations were visited daily for three years during the mosquito season. In addition to these routine counts, random sampling was carried out throughout the foothill area in order to fill in between the stations and to better assess the area affected. Presence and population density fluctuations correlated throughout this area, with the greatest variation in time of appearance of the flights being 24 hours, progressing from northwest to southeast. (Fig. 1).

Further attempts to define accurately the area of invasion were not made due to lack of time and personnel. It was not felt that complete definition of this area was necessary to the solution of the problem.

Early in the investigation it became apparent that the invaded area was so large and the numbers of mosquitoes present

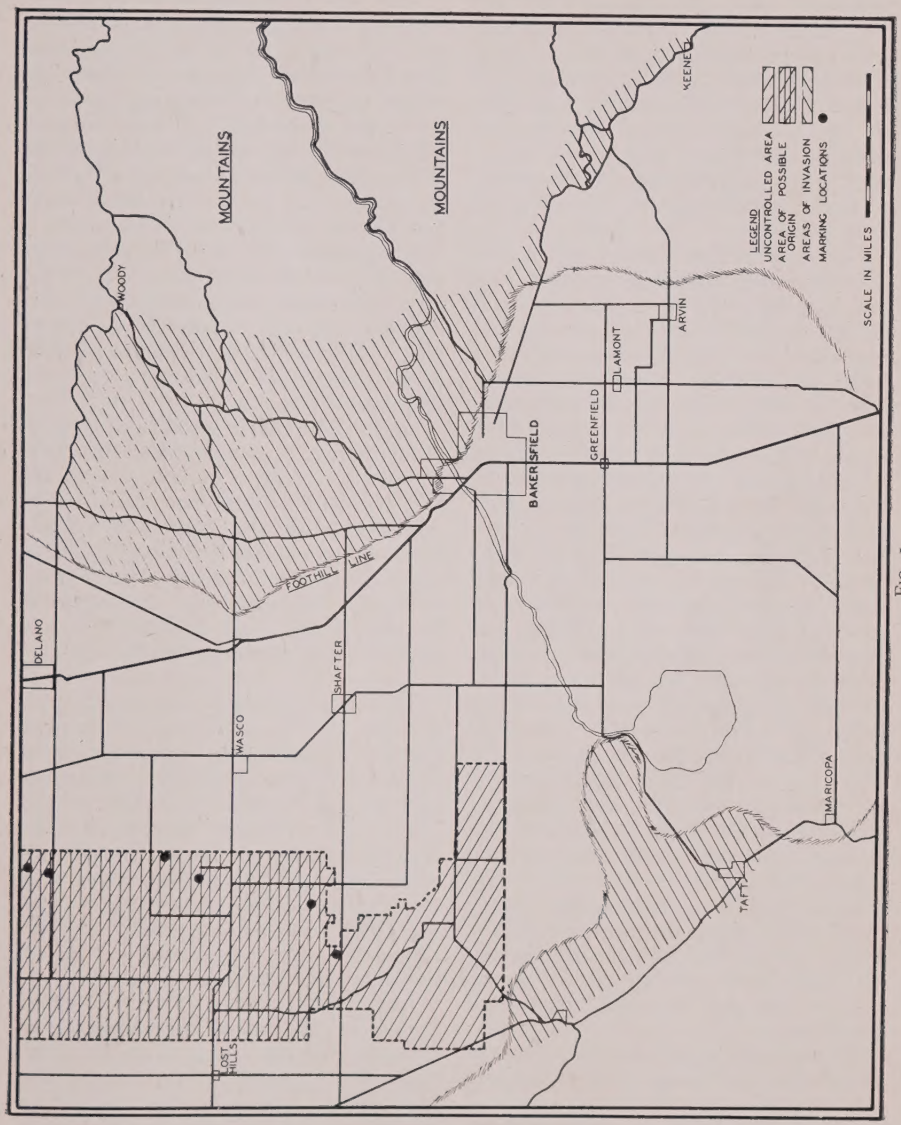
MOUNTAINS
MOUNTAINS
MOODY
FOOTHILL LINE
DELANO
SHAFTER
WASCO
LOST HILLS
BAKERSFIELD
GREENFIELD
LAMONT
ARVIN
KEENE
TAFT
MARICOPA
LEGEND
UNCONTROLLED AREA
AREA OF POSSIBLE ORIGIN
AREAS OF INVASION
MARKING LOCATIONS
SCALE IN MILES

FIG. 1

were such that if a single source was responsible, it must be of very considerable magnitude. The other possibility was that the mosquitoes were moving from an area with enough individual sources to build up a high adult population density, and that mass migrations from this area were set off by some natural phenomenon. Since no single large source could be located which might account for the pattern presented, consideration was turned to the other possibility.

Following the 1950 season, daily records of temperature, barometric pressure, relative humidity and wind direction and speed were obtained for the years 1949 and 1950 from the weather bureau station at Bakersfield. These data were broken down in various ways and plotted against the flight periods for these two years. The graphs were taken to the weather bureau for examination and analysis by the meteorologist. He found what he considered an excellent correlation between a recurrent meteorological pattern and the flight periods. The pattern consisted of a barometric gradient from the coastal area to the west into the valley. When this gradient occurs, cool air is drawn from the coast into the valley through a low area in the hills bordering the west side of the valley and striking primarily in the Lost Hills—Semi Tropic area on the west side of the valley. The effects of this gradient are three-fold. First, the cool coastal air moving down the gradient reduces the valley temperature several degrees. Second, the influx of air from the west moves the existing air mass in the valley easterly toward the foothills along the east side of the valley. Third, the cool air striking the hot valley floor sets up a very strong thermal updraft in the Lost Hills—Semi Tropic area.

A large part of the area first touched by this air mass is not in any mosquito abatement district. The land use pattern is one of scattered farms, most of which either border on or are close to undeveloped land. Excess irrigation water is wasted off onto this unused land, causing reflooding of the low areas with each irrigation and setting up very favorable conditions for flood water *Aedes*.

Since this meteorological pattern correlated with the flights over a period of time and the associated air mass movement struck an area of high *Aedes* breeding potential, this area was strongly indicated as the source of the flights. On the basis of the air movements set up by the invasion of the valley by this cool air mass, it could be hypothesized that the movement could take place in one or both of two ways.

First, a movement along the valley floor into the foothills with the displaced air mass and, second, a passive movement rising on the thermal currents, being carried up and over and deposited in the foothills as the thermal air cooled and came back down as convections.

Later, daily checks consisting of body counts at five locations on the valley floor between the Semi Tropic area and the eastern foothills gave no indication of movement along the valley floor. Daily counts at five stations along the western foothills, however, showed a fairly good correlation with those made in the eastern foothills, giving some emphasis to a possible thermal convection mode of transportation.

Since it was desirable from the standpoint of the Kern Mosquito Abatement District to define the origin of these flights as quickly as possible, and strong circumstantial evidence pointed to the Semi Tropic area as the source, it was decided to attempt marking in this area in 1951, using radio-active phosphorus as a tagging agent. Counting at the previously established stations and general area inspections would be continued to establish the pattern more firmly.

Although the marking with radio-active phosphorus did extend our knowledge of the proven flight range of *Aedes nigromaculis* in California to 7½ miles, it was considered a failure for the purposes of this study. The prime factor was probably inability to mark sufficient numbers of mosquitoes. Other factors were the necessity of releasing from a single point when the source was over a wide area and

the relatively short half-life of P^{32} which restricted marking to a fairly short period of time. Handling procedures require much special equipment and specially trained personnel. Tanks for holding larvae in P^{32} solution are stationary and release must be made from that point. The collection and transportation of larvae in hot weather may affect them adversely and limits the numbers of adults which may be released.

In the original consideration of marking media, dyes were discarded because of the time that would be involved in the development of techniques for marking and recovery; however, on second consideration, they seemed to avoid the basic faults of radio-active isotopes in regard to the specific problem at hand. Advantages that dyes seemed to offer were: non-hazardous dyes can be used freely throughout the source area wherever adult mosquitoes are available, and sprayed directly on the adult mosquitoes. Dyes can be applied on emerging swarms of mosquitoes whenever and wherever they are available, and handling presents no problem. By spraying dyes on adults the larval development is not affected in any way and almost limitless numbers of adults may be marked.

In preliminary field trials using fluorescene dye (navy sea marker) at 14 ounces in 2 gallons of water, emerging swarms of *Aedes* adults were sprayed with an 8002 Chicago Spraying Systems fan nozzle at the rate of approximately 4 gallons per acre. After 10 minutes, attacking adults were collected with a chloroform tube and returned to the laboratory, where they were immersed individually in 5 cc of water in a small test tube. Dye could be detected under a strong ultra-violet source in the rinse water from 70 percent of the mosquitoes so treated.

Further field trials with this material developed several problems, not the least of which was a natural fluorescence which leached out of the mosquitoes if they remained in the water for longer than a half hour or so. The color of this fluorescence under ultra-violet light was very similar to that of the fluorescene.

Other water soluble substances were tested and soluble Rhodamine "B" was finally selected for further trials. Although this material has a solubility of only slightly more than 0.25 percent in water, it was readily visible under ultra-violet light in dilutions as low as one part in 500 million.

Applications were made over emerging swarms in the field, using a 0.25 percent solution with Chicago Spraying Systems 8002 fan nozzle at 80 to 100 pounds pressure. Adults were collected from the body both before and one-half hour after the dye application for checking.

It was found that recovery of the dye by placing the mosquito on a sheet of white water color paper and placing a drop of absolute methyl alcohol on it was much more rapid and simpler than immersing mosquitoes in test tubes of water. The dye is transferred to the paper by the alcohol. The paper is then allowed to dry and is examined under an ultra-violet light. Using this method, 70 percent of the Rhodamine "B" sprayed mosquitoes were marked. No recoveries were made at any time from pre-application checks.

Due to the late beginning of the 1955 season, some of the planned developmental work was foregone. This included the use of stickers and spreaders, which might or might not have increased recoveries. Dye applications were made primarily with power sprayers.

A total of 25 dye applications were made over a period of 54 days. The applications were made on seven major *Aedes* sources lying roughly in a north-south line approximately 20 miles long, (see Fig. 1) and at right angles to the direction of the air mass movement suspected of initiating the flights.

Mosquitoes for dye recovery were collected in Wasco, Shafter and Wildwood, approximately six and eleven miles east and five miles south of the dye area, respectively, and in the foothill area of Bakersfield, approximately 28 miles east, southeast of the nearest dye location. Mosquitoes were collected primarily by body collections, 12 men spending from one-

half to three hours each morning. *Aedes* taken in eight routinely operated light traps were also examined.

A total of 21,990 mosquitoes were collected in the recovery areas and tested for dye. By far the greatest numbers were taken from the Bakersfield area. Sixty marked specimens were recovered from the Bakersfield area on 24 different days and 6 different flight periods. Twelve recoveries were made from the Wasco area and two from the Wildwood area. The majority of the Bakersfield recoveries (34) were made on three occasions, when a major dye application was followed immediately by a heavy flight into the foothill area.

Since a mosquito abatement district is not a research agency, there is much of interest that was left undone. We did not demonstrate the complete extent of dispersion and might have delved further into the meteorological aspects of the problem. Neither do we feel that we know the full extent of the area of origin of the flights. We do feel that we have demonstrated a mass movement of *Aedes* mosquitoes over a distance of 20 to 30 miles, and by extension to known correlated limits, over a distance of at least 58 miles.

A POPULATION STUDY OF THE *CULICOIDES* MIDGES[1] OF THE EDWARDS PLATEAU REGION OF TEXAS

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Early in 1953 it was definitely established that the virus disease of sheep known as bluetongue has been present for some time and is occasionally epizootic in the southwestern United States. In South Africa, where bluetongue has caused important losses to sheep raisers, and where it has been studied intensively for several decades, the only proved vectors are biting midges of the genus *Culicoides* Latreille (du Toit, 1944). D. A. Price and W. T. Hardy, veterinarians of the Texas Agricultural Experiment Station at Sonora, have produced bluetongue infections in sheep experimentally by inoculations of an emulsion of *Culicoides variipennis* (Coquillett) (fig. 1) made from specimens caught in a light trap on the station where an outbreak of the disease was in course (Price and Hardy, 1954). One of the first steps in planning an investigation on the habits and control of these biting midges was to determine which species were present in the outbreak area as well as their relative abundance and seasonal history.

GEOGRAPHY. The bluetongue outbreak area of western Texas is centered on the extensive sheep-raising region of the Edwards Plateau. The dissected edge of this limestone plateau forms the eastern border of the region at the Balcones Escarpment. The eastern portion of the plateau is hilly, with a subhumid climate. A scrubby forest of Mexican cedar, Texas oak, and stunted live oak forms the dominant vegetation. To the west, the plateau levels

[1] Diptera, Heleidae.

[2] Retired.

[3] We are greatly indebted to the personnel of the Agricultural Research Service laboratory at Kerrville and to D. A. Price and W. T. Hardy, veterinarians of the Texas Agricultural Experiment Station at Sonora, Texas, for assistance in this study.

Fig. 1. *Culicoides variipennis,* female (drawn by Arthur D. Cushman, Entomology Research Branch).

out towards and across the Pecos River, the climate becomes semi-arid, and the vegetation becomes a live oak-mesquite savannah (Blair, 1950). The location of the U. S. Department of Agriculture Experiment Station near Kerrville is typical of the hilly eastern section, while the Texas State Experiment Station near Sonora is in the level, more arid savannah country.

Methods. Earlier published works of James (1943), du Toit (1944), Fox and Kohler (1950), Wirth (1951), Beck (1952), Khalaf (1952), and Fox (1953) indicated that New Jersey light traps would attract large numbers of *Culicoides,* including a wide variety of species. During a preliminary survey by the senior author at the Kerrville station in June 1953, three light traps were operated at locations where they would sample different types of possible breeding places of *Culicoides.* A fourth trap was left with Dr. Price at the Sonora station to sample the population at a location where an outbreak of bluetongue was in progress.

The traps were standard New Jersey mosquito traps modified only by the substitution of a 14-by-18 mesh wire screen for the hardware-cloth screen at the top of the cylinder below the light, to keep out the larger beetles and moths which would injure the midges or otherwise hinder their identification.

Through the cooperation of the personnel of the Kerrville station, and of doctors at the Sonora station, each trap was operated all night two nights a week for the remainder of the 1953 season, and into the 1954 season. During the winter the traps were operated only during warm weather, which usually occurred about every two or three weeks. Dr. Price also used the trap at the Sonora station a few alternate nights to collect live *Culicoides* for transmission studies.

The junior author was responsible for the regular operation of the Kerrville traps and for shipping the specimens to Washington, where the senior author sorted out and counted the *Culicoides.* To save time, an attempt was made to divide the larger catches by making aliquot samples. Each aliquot contained about 0.1 pint of insects, which yielded 200 to 300 *Culicoides* to be sorted. The total catches were computed from the sample. This division was usually necessary only for the Luglan trap, which frequently caught more than a pint of insects, even with a screen.

In 1955, the senior author spent about six weeks in March and April at the Kerrville station searching for breeding places

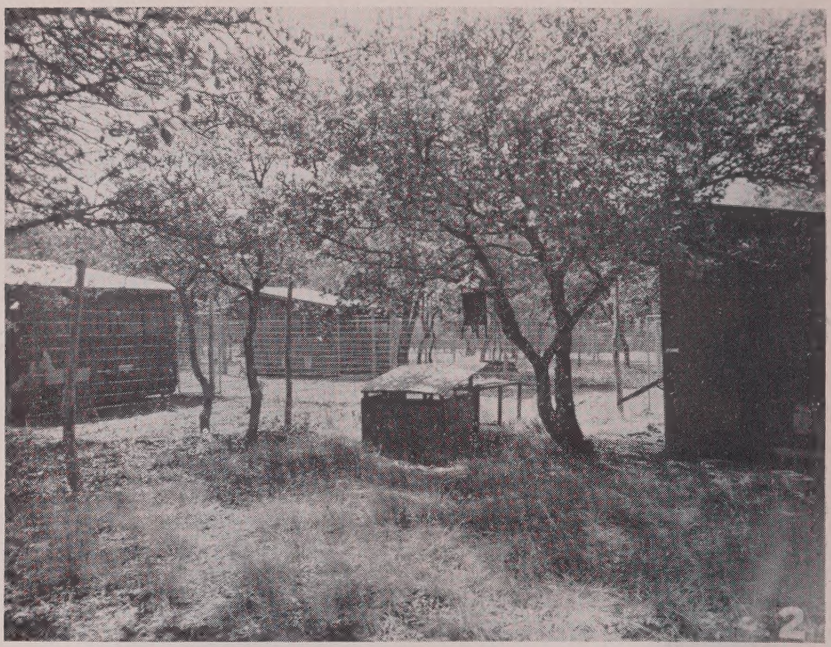


FIG. 2. Location of light trap at poultry yard, Kerrville station, showing characteristic scrubby oak-juniper forest (photograph by Rowland Richards, Entomology Research Branch).

FIG. 3. Location of light trap at impounded creek, Luglan Ranch (photograph by Rowland Richards).

Fig. 4. Location of light trap at Bottimer residence, showing characteristic post oak woodland (photograph by Rowland Richards).

Fig. 5. Location of *Culicoides variipennis* breeding area in sewage effluent seepage area at the Sonora Experiment Station (photograph by Rowland Richards).

of *Culicoides,* and made a few rearings from the vicinities of the light traps. These rearings are reported herein.

LOCATIONS OF LIGHT TRAPS AND RELATIVE ABUNDANCE OF DIFFERENT SPECIES. Trap I (figure 2) was placed in a poultry yard at the Kerrville station, which is about six and a half miles northeast of the city of Kerrville. The terrain was, in general, rather high and well drained. The nearest permanent stream was a creek which arose from springs about half a mile from the poultry yard and flowed past the Luglan Ranch (location of trap II). Smaller springs within several hundred yards of the poultry yard were temporary and had dried up several months before the trap was operated. Breeding places on the station near the trap were restricted to overflow and leaks from stock-watering tanks and troughs, manure piles and drains from livestock pens, damp leafmold and, judging from the large numbers of *arboricola* and *ousairani* caught, a considerable number of tree holes in the scrubby woods covering the entire area.

At the poultry yard (table 1) the commonest species was *haematopotus* (66.5 per night), followed by *arboricola* (55.2), *ousairani* (40.5), and *multipunctatus* (7.8).

Trap II (figure 3) was located at the Luglan Ranch about two miles north of the Kerrville station. A dam had been built across a small, cool permanent creek, forming a pond about 50–75 feet in width and a quarter of a mile in length in front of the house and gardens. The pond was heavily fertilized to support a high fish population for recreational purposes, and in consequence developed a high population of aquatic insects. The trap was set up on the shore at the lower end of the pond. A few hundred yards away the heavily watered lawn and garden and the ranch pens for a few sheep and horses afforded suitable breeding areas for less aquatic species.

At the Luglan Ranch *haematopotus* was by far the commonest species (135.9 per night), followed by *multipunctatus* (64.2) and *bottimeri* (53.5).

TABLE 1. Average Number of *Culicoides* Taken per Night in Texas Light Traps, June 1953 to June 1954, inclusive

Species	Poultry Yard	Luglan Ranch	Bottimer Residence	Sonora Station
arboricola	55.2	1.4	1.0	0.1
borinqueni	0.5	0.1	0.1	...
bottimeri	1.1	53.5	4.0	0.2
crepuscularis	4.2	27.5	0.7	5.3
haematopotus	66.5	135.9	22.9	0.3
hieroglyphicus	0.1	0.2	0.1	0.5
jamaicensis	0.2	0.1	0.6	1.8
multipunctatus	7.8	64.2	54.8	1.2
neopulicaris	1.8	2.9	0.3	...
ousairani	40.5	3.0	5.7	11.8
salihi	4.5	20.9	6.7	...
spinosus and *nanus*	3.3	20.9	0.7	0.1
stellifer	0.3	27.5	0.8	...
variipennis	1.2	4.2	0.8	210.2
weesei	...	...	...	...
n. sp. near *haematopotus*	...	0.5	0.2	...
Totals:	13,107	21,405	7,745	10,183
Number of nights operated	70	59	78	44
Average per night	187.2	362.9	99.3	231.4

Trap III (figure 4) was located at the Bottimer residence on the western edge of the city of Kerrville. A small portion of the lawn was heavily watered, and the most likely remaining breeding places consisted of several very large compost piles at the back of the lot and rot holes in several large oak trees. There was usually some direct competition from lights in the house, not present at the other localities.

At the Bottimer residence the commonest species was *multipunctatus* (54.8 per night), followed by *haematopotus* (22.9), *salihi* (6.7) and *ousairani* (5.7).

Trap IV was located at the laboratory building of the Sonora Experiment Station between Rocksprings and Sonora. In addition to tree holes and the usual occasional overflow from livestock-watering tanks and the watering of residential lawns and gardens, the largest and most productive source of breeding (actually determined by recovery of *variipennis* lar-

vae) was a heavily polluted seepage area of about half an acre fed by the sewer system for the station and opening about 300 yards from the trap (figure 5).

At the Sonora station there was an enormous population of *variipennis* (210.2 per night), with relatively few *ousairani* (11.8), *crepuscularis* (5.3) and other species.

SEASONAL ABUNDANCE. The average nightly catch of each common species of *Culicoides,* and the average total catch per night for all species by monthly intervals for a thirteen-month period from June 1953 through June 1954, are shown in figures 6 to 9.

Populations at the poultry yard and Luglan locations where *haematopotus* was dominant reached their maximum in August, and those at the *variipennis* locality at the Sonora station crested in September. The population at the Bottimer residence, where *multipunctatus* was most numerous, reached a much earlier peak, in April of 1954 and in June or before in 1953. An April, 1954 peak at the Luglan trap was higher than the August, 1953 peak primarily because of proportionally greater numbers of *bottimeri, spinosus,* and *stellifer,* which are also evidently more common in early spring. Populations of the common tree-hole species *arboricola* and *ousairani* apparently built up steadily and reached their peak in the hot summer months. Populations of *Culicoides* generally diminished rapidly in October, and adults practically disappeared by November first. In February a few specimens were taken in two of the traps, and by March full-scale emergence was in progress during warmer weather. Observations at the Kerrville station during 22 nights of trapping in March and April of 1955 indicated that there was very little adult activity on cool nights when the minimum temperature dropped below 55° F.

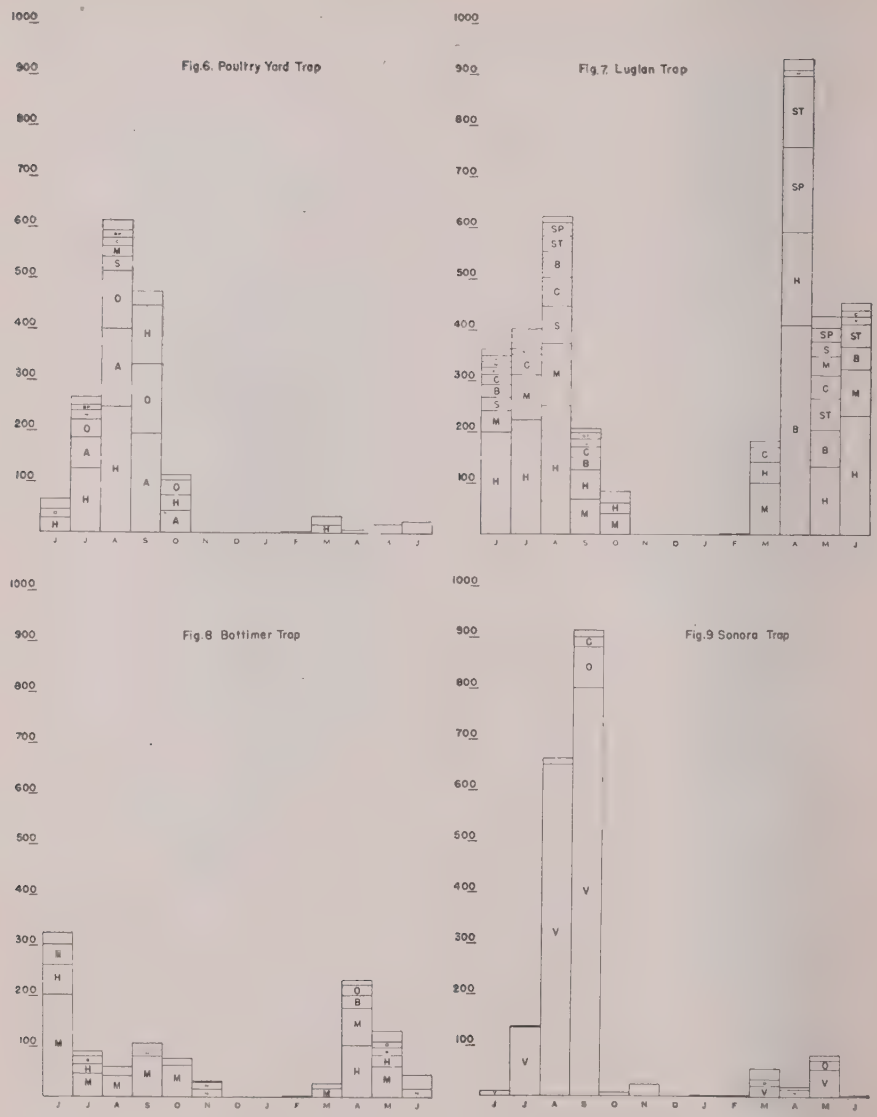
For unexplained reasons the populations in the poultry yard and Sonora traps were much lower in June of 1954 than in June of 1953. It is possible that the constant trapping seriously depleted the population of females before they oviposited. Weather or human activities may also have had some effect. We cannot say from our data whether the same depletion actually occurred at the Bottimer location or whether there was a shift in time of greatest emergence due to weather conditions or other factors. At the optimum aquatic Luglan location it is apparent that the population remained high the second season.

NOTES ON SPECIES OF *Culicoides* COLLECTED. 1. *C. arboricola* Root and Hoffman is a common tree-hole species in the Southeastern States, occurring from Maryland to Oklahoma and Texas. It ranked fourth in our Texas light traps, being most abundant at the poultry yard where there were many oak-tree rot holes. We reared it twice: from wet wood debris in a hollow stump at the Kerrville station in company with *ousairani,* and from a tree hole at the Bottimer residence in company with *nanus* and *borinqueni.* Earliest record, March 9; latest, November 4.

2. *C. baueri* Hoffman was not identified from light traps, but we reared it once, on April 4, from the muddy margin of the Henke pond about a mile from the Kerrville station, where it was associated with *haematopotus, stellifer,* and *crepuscularis.* This species occurs from coast to coast in the United States.

3. *C. borinqueni* Fox and Hoffman was described from tree-hole rearings in Puerto Rico, and it has also been reared frequently from tree holes in Virginia and Tennessee. It has been taken frequently while biting man. It was taken occasionally in the three Kerrville traps in the more heavily wooded section of the plateau. We reared it once from an oak-tree hole at the Bottimer residence, where it was associated with *arboricola* and *nanus.* Earliest record, May 6; latest, October 20.

4. *C. bottimeri* Wirth was described (Wirth, 1955) from specimens taken in the present study and is not known to occur outside the Kerrville area. It is common at Kerrville, ranking sixth in the total trap collections and third in the Luglan trap at the pond margin where we suspect it breeds. It has not yet been reared. Earliest record Mar. 30; latest, October 2.



FIGS. 6–9. Seasonal distribution of *Culicoides* species, showing average nightly catch per month in four Texas light traps, June 1953 to June 1954.

A—*arboricola*
B—*bottimeri*
C—*crepuscularis*
H—*haematopotus*
M—*multipunctatus*
N—*neopulicaris*
O—*ousairani*
S—*salihi*
SP—*spinosus* (+ *nanus*)
ST—*stellifer*
V—*variipennis*
Unlettered—other species

5. *C. crepuscularis* Malloch is a common Nearctic species, reaching its greatest abundance in open, unwooded country. It ranked only seventh in our trappings, but we reared it from twelve samples in 1955: from mud at pond margins, sand at pond margins, puddles at water tank overflows and septic tank effluents, where it occurred with *haematopotus, multipunctatus, baueri, stellifer, spinosus,* and *variipennis.* Earliest record, February 26; latest, October 31.

6. *C. haematopotus* Malloch was the most abundant species in our trap collections and rearings. It was the only species taken while biting man in the spring 1955 study, when it was caught twice while feeding. It was reared from 17 samples: from mud at pond margins, sand at pond margins and stream margins, but never when pollution was extensive. Associated species were *baueri, crepuscularis, spinosus, stellifer,* and *variipennis.* Earliest record, February 26; latest, November 6.

7. *C. hieroglyphicus* Malloch is a common species in the western states, as far east as the Great Plains, but is replaced in Texas and the Midwest largely by its close relative, *multipunctatus.* We took it only in light traps, a few specimens in early spring. Earliest record, March 1; latest, June 2.

8. *C. jamaicensis* Edwards is a Central American species ranging south to Jamaica and Panama. It belongs to the *copiosus* group of species which have been reared from rotting stems of cacti. It was fairly common at Sonora but scarcer in the more heavily wooded Kerrville area. Earliest record, February 18; latest, October 20.

9. *C. multipunctatus* Malloch is a midwestern species occurring from Illinois to Texas. It seems to be more abundant in the southern part of its known range, ranking third in our light-trap collections. We reared it in 1955 from four samples from mud at pond margins, where it occurred with *crepuscularis* and *haematopotus.* Earliest record, February 26, latest, November 4.

10. *C. nanus* Root and Hoffman is a fairly common southeastern tree-hole species. In our earlier determinations this species was confused with *spinosus,* which it closely resembles, but a recheck of pooled samples indicates that it is at least a tenth as common as *spinosus,* and probably more abundant in the wooded areas where tree holes are numerous. We reared *nanus* once in 1955, from an oak tree hole at the Bottimer residence, where it occurred with *arboricola* and *borinqueni.*

11. *C. neopulicaris* Wirth is a Mexican species known to occur from Kerrville to the Balsas Valley of southern Mexico. It was fairly common in the Kerrville traps, but was not taken at Sonora nor was it reared. Earliest record, March 9; latest, October 23.

12. *C. ousairani* Khalaf is a southwestern representative of the *guttipennis* group of tree-hole species. It was common in all our traps, ranking fifth in abundance. We reared it once, from a hollow tree stump where it was associated with *arboricola.* Earliest record, March 9, latest October 23.

13. *C. pecosensis* Wirth was not taken in the Kerrville and Sonora traps, but is included in the Edwards Plateau list of species because it occurs in the Trans Pecos section known as the Stockton Plateau. It is known only from light-trap collections made at Sanderson, Texas, in April and August by personnel of the Kerrville station. It belongs to the *guttipennis* group of tree-hole breeding species.

14. *C. salihi* Khalaf is known only from the Wichita Mountains of Oklahoma and the Edwards Plateau of Texas. It was fairly common at Kerrville, ranking eighth in total frequency, but was not taken in the Sonora trap. It has not been reared. Earliest record, April 27; latest, October 23, a relatively late-season species.

15. *C. spinosus* Root and Hoffman is a common species east of the Rockies, breeding in stream and pond margins and similar aquatic habitats. We reared it four times in 1955, from mud at pond margins. Earliest record, March 9, latest October 9.

16. *C. stellifer* (Coquillett) is a common

species over the entire United States. It was taken in large numbers only in the Luglan trap and we reared it twice from mud at pond margins. Earliest record, April 7, latest October 2.

17. *C. variipennis* (Coquillett) is common over the entire United States and southern Canada and ranges into the temperate parts of Mexico. This species is apparently a complex of several closely related subspecies and populations with somewhat different habits and morphological characteristics which may assume importance in future studies on disease transmission and control methods. In the East the species is not common and breeds principally in barnyard drains and sewer effluents. In the West it is a dominant form in saline and alkaline aquatic habitats, and around municipal sewage farms and other polluted water. Muddy margins of stock ponds (figure 10) and streams and puddles in pastures are favored breeding places near livestock. This species was scarce in the Kerrville traps but extremely abundant at the Sonora station where bluetongue outbreaks occur frequently. The larvae could be taken by thousands in each small cup of mud from a sewer effluent on the station. In 1955 we reared *variipennis* from ten samples, in small numbers from mud and sand at pond margins where the water was fresh and in very large numbers from heavily polluted mud. Earliest record January 30; latest, October 27. This species apparently is active sporadically during the winter months when the minimum night temperature does not drop below 60° F.

18. *C. weesei* Khalaf is found only in the drier parts of Oklahoma and western Texas. We identified four specimens collected in the Luglan trap on March 9, 1954. This species was taken more frequently in traps operated west of the Pecos River by Kerrville station personnel.

FIG. 10. Location of *Culicoides variipennis* breeding area at muddy margin of a stock pond on a ranch in western Kerr County, Texas, where a bluetongue outbreak occurred (photograph by Rowland Richards).

19. *Culicoides* new species near *haematopotus*. Forty-three specimens were taken in the Luglan and Bottimer traps. Earliest record, April 27; latest, July 2.

Conclusions. A very gratifying feature of this light-trap study was the constancy of the total number of species caught in each location. Ten species were consistently caught in each location. Four additional species (*borinqueni, neopulicaris, salihi,* and *stellifer*) were caught only in three traps in the more moist Kerrville area. The Sonora location was probably unsatisfactory for them. Two additional species were caught less regularly: *weesei* only in the Luglan trap and "new species near *haematopotus*" in the Luglan and Bottimer traps only. We feel that we have recovered all of the important species, although we have undoubtedly missed a few rare ones or a few which are not attracted to light. In this category is *baueri,* which we reared but did not find in light-trap catches. In spite of the marked difference in habitat reflected between the poultry yard, Luglan, and Sonora traps, the average nightly catch for each—187.2, 362.9 and 231.5 respectively—showed good correlation and represented a high population level. For some reason the Bottimer trap (99.4 *Culicoides* per night) was a much poorer location.

Although catches at the three Kerrville traps, especially the Luglan trap, probably reflect the nature of *Culicoides* populations under optimum conditions for the eastern Edwards Plateau, it is believed that the population at the Sonora station trap is more representative of the more arid, sheep-raising country where bluetongue has occurred. This belief is supported by the results of 82 nights of light-trapping by personnel of the Kerrville station at scattered ranch localities from Kerrville to the Pecos River and from Del Rio to San Angelo, which are not reported here. At nearly all of these localities, as well as at Sonora, the population of *variipennis* was comparatively high. This species is known to breed in very high concentrations in polluted puddles of barnyards, in sewage farm irrigation systems, and at the margins of saline and alkaline ponds throughout the western United States. According to our present information, this habitat preference would bring the species into closer contact with sheep and other livestock than happens with other species. For this reason, *variipennis* is the primary suspect in the search for the principal vectors of bluetongue in North America.

Summary. Four light traps were operated at regular intervals in ecologically different areas in and near the Edwards Plateau region of Texas, where the bluetongue disease of sheep was present, in order to compare the prevalence of possible vector species of *Culicoides* in each habitat and to record their relative numbers through a complete annual cycle. A total of 52,440 individuals, representing 17 species of *Culicoides,* were taken in the four traps during 251 trap-nights of operation. Nearly all species appeared in large numbers with warm weather, in early March, and continued at a constant level until late October. In the three wooded and better watered locations in and near Kerrville, Texas, where bluetongue occurred sparingly, the commonest species were, in fairly close order, *haematopotus* Malloch, *multipunctatus* Malloch, *arboricola* Root and Hoffman, *ousairani* Khalaf, *bottimeri* Wirth, and *crepuscularis* Malloch. At the extremely arid Sonora Experiment Station, where bluetongue was prevalent, *variipennis* (Coquillett) outnumbered all the remaining species combined, by nearly thirteen to one. Average numbers of *Culicoides* caught per night were 187, at a poultry yard on the Kerrville station; 363 near a pond on a nearby ranch; 99 at a residence in the city of Kerrville, and 231 at the Sonora station.

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A SURVEY OF THE PUBLIC HEALTH IMPORTANCE OF PEST MOSQUITOES IN THE MILK RIVER VALLEY, MONTANA*

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INTRODUCTION. It is recognized that mosquitoes create public health hazards in addition to the transmission of diseases, but there is very little specific information available on this subject. The present report summarizes an initial survey to evaluate the impact of pest mosquitoes upon the health and welfare of a community in the Milk River Valley of northern Montana, where a severe mosquito problem has existed for a number of years.

The town of Chinook was selected for the survey because investigations by a field unit of the Logan Field Station located there during the past four years had defined the nature and extent of the mosquito problem. The mosquito problem in the Chinook area is representative for the Valley as a whole, being intermediate between the least and the most severe. Human biting records indicate that the most important mosquito species involved are: *Aedes vexans, A. idahoensis, A. dorsalis, A. nigromaculis, A. trivittatus,* and *Culex tarsalis* (the common encephalitis mosquito).

The survey was conducted during the period September 7–10, which is well beyond the peak of mosquito activity, frost occurring during the last two days of the survey. Although this decreased the opportunity for observing certain signs of reaction to mosquito bites, it probably minimized the chances of obtaining exaggerated histories such as might occur during the period of most severe annoyance.

PROCEDURES. The data were obtained by a house-to-house survey in an area two blocks wide around the perimeter of Chinook, a town of approximately 2,400 population. The area surveyed constituted about one-fourth of the town and the residences were representative of both the lower and middle income groups with a scattering of higher. Eight rural premises in the general area were surveyed for comparative purposes.

The data were obtained by verbal questions usually answered by the mother and/or father of each family. Three types of information were obtained with regard to the 1955 mosquito season (May to September): (1) the householders' evaluation of the overall effects of mosquitoes upon their families; (2) an estimate of the direct effects of mosquito bites upon indi-

* From the Communicable Disease Center, Public Health Service, U. S. Department of Health, Education, and Welfare, Logan, Utah.

viduals from histories given to the questioning physician and from signs he observed on examination of faces, extremities, and other exposed areas of children and housewives; and (3) the nature and extent of treatments for mosquito bites as reported by householders.

Additional data on medical treatment of mosquito bites and human cases of encephalitis were obtained through contacts with local physicians and hospitals.

Results. The results of the survey are summarized in table 1. With regard to the effects upon the family, three-fourths reported severe annoyance from mosquitoes, about half of them said that mosquitoes prevented children from playing out of doors for 2 to 4 months during the summer, and three-fourths of them stated that mosquitoes interfered with outdoor activities such as gardening. Outdoor cooking and barbecueing, which is so popular over most of the country, is practically non-existent in Chinook, only one unused barbecue pit having been observed during the survey. There was very little evidence of any outdoor community activities, and a number of individuals commented that mosquitoes made such activities impossible. It was reported that in one church without screens it was most difficult to hold successful meetings during the mosquito season.

The survey indicated that most of the

TABLE 1.—Results from House-to-House Survey of Public Health Importance of Mosquitoes, Chinook, Montana, September 7–10, 1955

	Class of Residence		
	Lower Income	Middle and Upper Income	Totals
Effects of mosquitoes upon families			
Number of families interviewed	33	100	133
Percent of families reporting the following:			
Annoyance by mosquitoes: Light	9	5	6
Moderate	24	19	20
Severe	67	72	73
Children prevented from playing out-of-doors for 2–4 months in summer	42	48	47
Interference with gardening and other outdoor activities of adults	64	77	74
Effects of mosquito bites upon individuals			
Number of individuals in interviewed families	156	426	582
Percent for which following symptoms reported:			
Irritation and itching	81	80	84
Swelling and redness	68	83	83
Welts	17	20	22
Abrasions from scratching	19	23	22
Infected bites	10	4	6
Number of individuals examined by physician	30	53	83
Percent with following signs:			
Edema and erythema	40	43	42
Wheals	0	4	2
Abrasions	67	49	55
Infections	40	6	18
Treatment for mosquito bites			
Percent of families which:			
Used home treatments	42	64	59
Used repellents	33	62	55
Used ointments, lotions, etc.	30	29	29
Took children to physician	6	2	3

individuals in the area reacted to mosquito bites with irritation, itching, swelling, and redness; more than one-fifth developed welts and suffered abrasions from scratching (especially the children); and 10 percent of the lower income group and 4 percent of the higher group reported infected mosquito bites. The percentage of individuals observed by the physician with equivalent signs was much lower in the case of edema, erythema, and wheals; this was to be expected since the survey was made sometime after the peak of mosquito annoyance and these signs are those which would disappear within a short time after the bites were inflicted. On the other hand, the amount of abrasions and infections observed by the physician was much greater than reported from the histories, particularly for families in the poorer dwellings. It was noted that individuals would frequently report that their families had not had any infected mosquito bites when a casual glance at their children standing beside them would reveal infected bites. One severe case was observed in which the ankles of an infant were covered with impetiginous abscesses which were secondarily infected mosquito bites.

Over half of the families reported using some sort of home treatment for mosquito bites, and the use of repellents was particularly prevalent. Among the home remedies used were rubbing alcohol, ammonia, witch hazel, calomine lotion, mercurochrome, merthiolate, Lysol, salt, baking soda, Vicks Vapo-Rub, Mentholatum, Camphophenique, and various salves and ointments including sulfa, penicillin, and cortisone. Four histories were obtained of children who had to be taken to a physician because of mosquito bites. Contacts with local physicians revealed a total of eight cases of mosquito bite infection or allergic reaction, two of which required hospitalization. The eye of one child swelled shut from the allergic edema caused by many mosquito bites on the face.

The survey also revealed four cases of human encephalitis which occurred during 1954, one of which was fatal. One of these was confirmed as Western equine encephalitis through serologic test, and the other three were based on clinical diagnosis alone.

The survey results from the 8 rural premises were quite similar to those obtained from the town. They provided some incidental evidence of the economic importance of mosquitoes in causing cattle to mill around, remain in barns, etc., and thus be prevented from feeding. Four farmers estimated that mosquitoes were directly responsible for an annual weight loss per calf of 75 to 150 pounds, with greater losses in older cattle.

Other evidence of the socio-economic importance of mosquitoes was observed within the town. For example, the operator of an outdoor ice cream and dairy products store reported that his profits were reduced by 25 percent during the summer months because customers would leave rather than tolerate the intense annoyance of mosquitoes; the operator of a diesel service station reported that mosquitoes caused many of his customers to be diverted to a mosquito-free station. Additional information is needed on the socio-economic importance of mosquitoes.

CONCLUSIONS. The results of the survey indicate that in the Chinook area of the Milk River Valley mosquitoes create a serious public health problem in addition to the transmission of specific diseases. This is evidenced by the fact that: (1) healthful outdoor activities of a majority of the families are greatly inhibited by mosquito annoyance; (2) most of the inhabitants endure deleterious reactions from mosquito bites; and (3) over one-fifth of the population suffer from scratching and secondary infections or allergic reactions, some of which even lead to hospitalization. It appears quite likely that in many other areas of the country so-called "pest mosquitoes" create similar health hazards.

CONVERSION TABLES FOR LARVICIDE APPLICATIONS

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Mosquito-control workers frequently have occasion to convert larvicide applications from pounds of toxicant applied per acre to parts of toxicant per million parts of water, or *vice versa.* Several years ago the personnel of the Corvallis, Oregon, laboratory felt the need for reference tables whereby these conversions could be quickly made. W. W. Yates, now retired, prepared the original tables which were used successfully at Corvallis and elsewhere. The tables have now been modified slightly, and it is believed mosquito-control workers will find the tables useful in much of their everyday work. They have been found particularly useful in connection with experiments on the control of mosquito larvae in irrigated areas. Frequent reference is also made to the following unit equivalents:

1 acre=43,560 square feet
1 cubic foot=7.48 gallons
1 acre-foot=43,560 cubic feet=325,829 gallons
1 gallon of water=8.337 pounds
1 pound=453.59 grams

Pounds per acre equivalent to parts per million (wt/wt) in water at different depths

Parts per Million	Pounds per acre in Water at Indicated Depth		
	1 Inch	4 Inches	1 Foot
1.0	0.226	0.904	2.716
.9	.203	.814	2.444
.8	.181	.723	2.173
.7	.158	.633	1.901
.6	.136	.542	1.630
.5	.113	.452	1.358
.4	.090	.362	1.086
.3	.068	.271	.815
.2	.045	.181	.543
.1	.023	.090	.272

Equivalent dosages of insecticides applied to flooded areas on the basis of pounds per acre

Pounds per Acre	Grams per Acre	Grams per 100 Square Feet	Parts per Million (wt./wt.) in Water		Million Parts of Water per Part of Insecticide at 12 Inch Depth
			12 Inches Deep	1 Inch Deep	
0.005	2.27	0.0052	0.00184	0.02208	543.5
.010	4.54	.0104	.00368	.04416	271.7
.015	6.80	.0156	.00552	.0662	181.1
.025	11.34	.026	.00920	.110	108.7
.050	22.68	.052	.0184	.221	54.3
.075	34.02	.078	.0276	.331	36.2
.10	45.36	.104	.0368	.442	27.2
.15	68.04	.156	.0552	.662	18.1
.20	90.72	.208	.0736	.883	13.6
.25	113.4	.26	.0920	1.10	10.9
.50	226.8	.52	.184	2.21	5.43
.75	340.2	.78	.276	3.31	3.62
1.00	453.6	1.04	.368	4.42	2.72
1.25	567.0	1.30	.460	5.52	2.17
1.5	680.4	1.56	.552	6.62	1.81
2.0	907.2	2.08	.736	8.83	1.36
2.5	1,134.0	2.60	.920	11.04	1.09
3.0	1,360.8	3.12	1.104	13.25	.906

NOTES ON *CULICOIDES* IN ALASKA
(Diptera, Heleidae)

R. I. SAILER,[1] E. P. MARKS,[2] AND S. LIENK [3]

The following observations on Alaskan punkies (*Culicoides*) are based for the most part on data accumulated by the Alaskan Insect Control Project during 1948. The project was directed by the former Bureau of Entomology and Plant Quarantine under funds transferred from the Department of Defense. Some additional data were obtained by the senior author during the summers of 1951 and 1953.

We acknowledge the generous assistance of Alan Stone and W. W. Wirth, of the Entomology Research Branch, U.S.D.A., in providing identifications. We are also indebted to Cpl. B. L. Morris, Air Force weather observer, who accompanied the survey party in 1948 from August 22 to September 8 and recorded data on adult activity of black flies and punkies. He also collected many of the specimens associated with the data. B. V. Travis, project leader; and J. D. Gregson, Canadian liaison officer, assisted in the initial attempts to find and rear immature *Culicoides tristriatulus* Hoffman.

So far as the Project was concerned, the *Culicoides* work was of secondary importance and no attempt was made to conduct a sustained study program on these insects. Nevertheless, numerous observations were made which add to the existing information on the biology, distribution and pest importance of the Alaskan punkies.

PREVALENCE AND IMPORTANCE. In addition to observations made at Anchorage, Valdez, and Fairbanks, data on abundance and flight habits were obtained from stations along the entire Alaskan highway system during two survey trips. The first trip was made between July 9 and July 25, the second between August 22 and September 8, 1948.

During the first trip, punkies were encountered in numbers sufficient to be included in routine landing counts * at only 3 out of a total of 173 stations (Valdez area excluded). During the second trip, punkies were encountered at 14 out of 151 stations, and at 10 of the 14 landing counts were more than 10.

Fourteen encounters with the punkies during a trip covering 18 days and 1,000 miles of highway may not be impressive, but the significance of this number of observations is greatly increased when it is weighed against factors known to affect flight activity of punkies. Perhaps the most important of these factors is the time during which the observations were made.

Most of the stations were visited between 8 a.m. and 6 p.m. At Valdez a series of observations indicated that activity was declining by 8 a.m. while the evening peak was not reached until after 7 p.m. It should also be noted that, even though the population at Valdez was numerous enough to produce peak counts of 200, a series of 11 observations made August 25 between 8 a.m. and 6 p.m. produced only 5 positive counts. Of the remaining 6 only 1 observation could be disregarded because of unfavorable wind or temperature conditions. This suggested that at Valdez the chance of encountering a positive punkie count at any randomly selected time between 8 a.m. and 6 p.m. was 1 in 2.

Of the 151 observations taken at high-

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* Number of punkies landing on the front and back of two fully clothed men during a 68-second period. The count period followed a 5-minute period during which weather observations were recorded.

way stations, 38 were made under either wind or temperature conditions that would prevent flight activity. If the 1-in-2 figure found at Valdez was applicable to the 113 remaining stations, 56 might have produced positive counts. The fact that 14 were positive could mean that approximately 21 percent of the area traversed by highways was infested by a measurable population of punkies during the time of the second survey trip in 1948. This would assume that both punkie populations and observation stations were randomly distributed. Actually no punkies were encountered at elevations higher than 2,800 feet, and since at least 20 of the 113 observations were made at stations above that elevation, punkies were accordingly more common in lowlands than the figures cited above would indicate.

The most severe punkie annoyance noted in Alaska during 1948 was observed at Valdez (see Fig. 1). There, a large population of *Culicoides tristriatulus* was present in the city and on the nearby tidal flats as early as June 18. During the first half of July, dock workers were compelled to wear head nets and gloves during periods of most intense punkie activity. The periods usually lasted for about 2 hours each morning and evening. Residents of the city seldom tried to work in their yards or gardens during these hours, and a swarm of punkies would accompany anyone who walked along the street.

The punkie population was most abundant on the tidal flats adjacent to the city. However, observations made on July 7 between 7:05 and 9:05 p.m. showed *tristriatulus* to be present in the valley up to 7 miles northeast of Valdez. The number of individuals diminished rapidly beyond 2.5 miles from the city. Punkies remained numerous until after the middle of July, when aerial spray greatly reduced their numbers and adverse weather restricted the flight activity of survivors. Local residents credited the reduction to the spraying operations, but they also expressed the opinion that the population normally declined after the middle of July.

When Valdez was revisited on August 24 and 25, *tristriatulus* was still numerous along the tidal flats, but none was seen in the city. At this time the two-man landing count did not exceed 200. In July the

Fig. 1. Aerial view of Valdez, Alaska. Typical of southeastern coastal areas where *Culicoides tristriatulus* Hoffman is a problem. Arrow points to site of adult activity studies.

count was often above 300 punkies landing in a minute on a dark felt hat worn by one observer!

Near Anchorage punkies were seldom encountered except on the tidal flats along Cook Inlet, where they were most prevalent between August 9 and September 15. The highest counts were observed on the flats near Eklutna. Here the standard two-man count reached 40, at times when conditions were nearest optimum for flight activity. *Culicoides yukonensis* Hoffman was the predominant species in samples collected at Eklutna.

In mid-July of 1951 *Culicoides yukonensis* was causing the residents of Fort Yukon serious annoyance. Many children had suffered severely from bites which the townsmen attributed to "gnats." We found that few people distinguished between the Simuliidae and the Heleidae. The former were often numerous and annoying, although they seldom bit. It was obvious from the characteristic appearance of the bites that the less conspicuous punkies were the source of most of the trouble. The population was about as numerous as that observed at Valdez on August 25–26, 1948. Punkies were much less numerous at Fort Yukon in 1953, the counts being less than 10 percent of those obtained in 1951. This difference might reflect a seasonal factor, since the observations in 1953 were made a week earlier than those of 1951.

In general, it appears that punkies are most likely to be of serious importance along the south and southeastern coast on or near extensive tidal flats. At Valdez the problem was found to be most serious during July but to persist in a diminishing degree until September. In the interior of Alaska nuisance populations may be encountered in low land or poorly drained areas from early July to mid-September.

Wherever encountered, punkies were aggressive biters. Often, when only a few were around, they would land, bite, and escape, leaving only a reddening spot as evidence of their presence. On the tidal flats near Valdez in July 1948, exposed personnel suffered a degree of annoyance that was fully equal to that caused by the pest population of mosquitoes prevalent in the Fairbanks area in the same year. At Fort Yukon in July 1951 the punkies caused much more annoyance than the unusually low mosquito populations present that year.

The effect of heleid bites was observed to vary considerably from person to person. For most people the bites are less troublesome than those of simuliids and perhaps more troublesome than those of mosquitoes. A person exposed to a large population of punkies soon looks like a measles patient. The spots itch with an accompanying burning sensation, and on some people they may persist for three or four days. Despite their numbers and aggressive behavior, the punkies at Valdez never entered houses, and those already crawling or even feeding on a person would take flight as soon as their host entered a tent or other shelter.

LARVAL HABITAT OF *Culicoides tristriatulus* HOFFMAN. Following our observations in 1948, Williams (1951) spent the summer of 1949 at Valdez, where he made an intensive study of the bionomics of *Culicoides tristriatulus*. Our observations at Valdez were limited to two weeks between July 2 and 17, but during the last week in July we obtained some additional information at Fish Creek Flats near Anchorage.

Most of our data were negative, and much of the information we did obtain was obtained independently by Williams. From Williams' observations it is apparent that our attempts to locate immature stages were misdirected. He found larvae and pupae concentrated in a zone of the "flats" that was covered by 80 to 90 percent of all daily high tides or along the banks of fresh water streams which were covered by overflow water at each daily high tide.

Of approximately 50 muck samples that were tested for larvae, 8 were taken from a marshy area near Robe Lake about 4 miles inland from Valdez; most of the others came from a marshy part of the

tidal flat west of town. The samples were taken along a 300-yard transect from the road to the base of the mountain. All were negative except two, from which 3 pupae were recovered. The two positive samples came from the lowest part of the transect, near the outer limit of the high-tide zone in which Williams found larvae to be most numerous.

Our second attempt to find and rear immature *Culicoides* resulted in the discovery of heleid pupae on the surface of a 1-inch-deep pool on Fish Creek Flats a short distance southwest of Anchorage (see Fig. 2). This pool was covered by some high tides, but was well above the zone covered by average daily high tides. *Scirpus pacificus* Britton was the predominant plant growing in and about the pool. The pool was visited on July 26 and again the following day and a total of 16 pupae were collected and placed in rearing tubes. The first adult emerged the same day and the last emerged on July 30. Of the 14 adult *C. tristriatulus* which emerged all but one were females. The two remaining specimens were species of *Dasyhelea*.

On July 27, seven muck samples were taken at the same pool; all samples contained heleid larvae and pupae. Seven apparently mature larvae and 15 pupae were removed for rearing. Two of the larvae pupated and the one that emerged was *C. tristriatulus*. Eleven of the pupae also produced *C. tristriatulus*. The remainder were *Dasyhelea* and *Bezzia*.

On July 29, 13 muck samples were taken along a line running the length of the flats parallel to Fish Creek. One sample taken 200 yards downstream from the pool where the July 26–27 collections were made was found to contain numerous small heleid larvae. The characteristics of this pool were very similar to those of the first. All other samples were negative. Three additional *C. tristriatulus* emerged from pupae collected on this date from the original pool.

Additional samples taken from the original pool on August 2 and 9 contained

Fig. 2. Fish Creek Flats near Anchorage, showing habitat of immature *Culicoides tristriatulus* Hoffman.

numerous small heleid larvae but no additional mature larvae or pupae were found. Samples taken August 16 from a *Triglochin-Scirpus* marsh on Eagle River Flats located north of Anchorage also contained large numbers of very small heleid larvae.

ADULT ACTIVITY OF *Culicoides tristriatulus* HOFFMAN. An intensive study of the effect of weather on the flight activity of *C. tristriatulus* was undertaken at Valdez between July 2 and 17. This study was primarily concerned with flight activity as reflected by the landing rate. The results have been reported by Pratt (1949). Observations on two other aspects of adult behavior are recorded below.

(1). Male swarms of *C. tristriatulus* were seen about 7 p.m. on July 2. Our party had just arrived at Valdez and equipment for detailed weather observations had not been unpacked. Since numerous swarms were seen, we assumed that there would be subsequent opportunities for detailed study. This did not prove to be true, for no additional swarms were seen, although the area was under close observation through July 17.

The swarms observed on July 2 were made up of a few dozen to several hundred individuals. They hovered at an elevation of about 8 feet, and their location remained unchanged during an observation period of about 5 minutes. All specimens captured by sweeping through the swarms with a collecting net were males. About 6 swarms were seen, all located on the tidal flats west of Valdez in the area crossed by the road to Mineral Creek. The weather was fair, sun low in the sky, temperature about 60° F., and wind velocity less than 0.5 mile per hour.

(2). Observations were made on the hiding place or shelter sought by the adult *tristriatulus* during times when conditions were not favorable for flight. Extensive sweeping of the vegetation on the tidal flats, as well as at the edge of the flats, gave meager results. On one occasion several punkies were taken by sweeping 6 to 8 inches above the ground through the scattered vegetation of the flats, about 600 yards from the edge of the woods. These specimens were taken at 7 p.m. on July 14, just before a period of intense flight activity.

Whether these adults were flying or resting was not determined.

On July 15, eleven men, assigned to test various repellents, were spaced at 20-yard intervals in a line running from the woods out on to the flats. The line was formed as the wind velocity dropped and before punkie flight activity started. The first landings were reported about 200 yards from the edge of the woods. Tests were repeated once during each of the two following days. On both days the line was formed before any punkies appeared. On July 16 punkies were first seen flying in the low vegetation about 40 yards from the edge of the woods. A few seconds later landings were reported at this point and subsequent landings followed progressively in both directions. On July 17 the first landings were reported simultaneously at the edge of the woods and at 40 yards out on the flats.

During the line test on July 16 one of the men reported seeing a punkie crawl out of the moss on the ground and fly away. Two more punkies, both female, were obtained by pulling the moss apart and digging among the tangled grass roots. These were about one inch below the surface of the moss. A third specimen was found among grass roots beneath a log. At another place several adults were found when a rotten log was rolled over. These specimens were crawling about on the moist under-surface of the logs. Others were seen to land on the log and crawl quickly into cracks and holes. These observations were made during a period of intense flight activity. On July 17 punkies were again found under logs and in grass roots. They were seen at 5 a.m. when large numbers were in flight and again at 8 a.m. when none were flying.

These observations suggest that adults of *tristriatulus* find shelter in almost any dark, moist retreat that is available in the area where they may be at the end of

favorable flight conditions. The fact that specimens were found among tangles of grass roots as much as one inch below the surface of the ground emphasizes the importance of timing the application of adulticides to coincide with periods of maximum flight activity.

Larval Habitats of *Culicoides yukonensis* Hoffman. In 1948 nothing was known concerning the habitat of immature *Culicoides yukonensis*. Quite by accident we obtained information concerning adult emergence from a breeding site in the Fairbanks area.

On June 5, we placed an emergence trap in a stream one mile north of College, Alaska. The trap was designed to capture emerging simuliids and consisted of a 3′×3′×3′ packing box that was light proof except for two openings near the top into which fruit jars were fitted. These jars were set at an angle and contained some alcohol into which the specimens fell and were preserved. Figure 3 shows the stream as it appeared when the trap was put in place and Figure 4 shows the trap in the position where it remained until September.

In addition to thousands of Simuliidae the trap captured 89 *Culicoides yukonensis*. The first punkie was captured June 19 and the last was taken July 2. Males were taken daily during the two-week period but more than half emerged June 26 through 29. The first female emerged June 25 and more than three-fourths of the 29 females captured were taken during the last four days of the emergence period. Sixty males to 29 females suggest a 2:1 sex ratio.

The stream in which the trap was placed was from 1 to 3 feet wide during most of the season, and ranged from 6 to 10 inches deep. Stream flow was less than ¾ foot per second. The bottom consisted of muck with some fine gravel where current was most swift. The stream channel was choked by trailing *Carex* and was unshaded except for emergent vegetation and tall grasses growing along the banks. The trap was near the outlet of a shallow, 20-acre bog-margined lake. The watershed consisted of about 2 square miles of poorly drained land sparsely covered by brush and second growth spruce and birch. The water carried a heavy organic stain during most of the summer, but was almost clear in May when runoff was heaviest. The

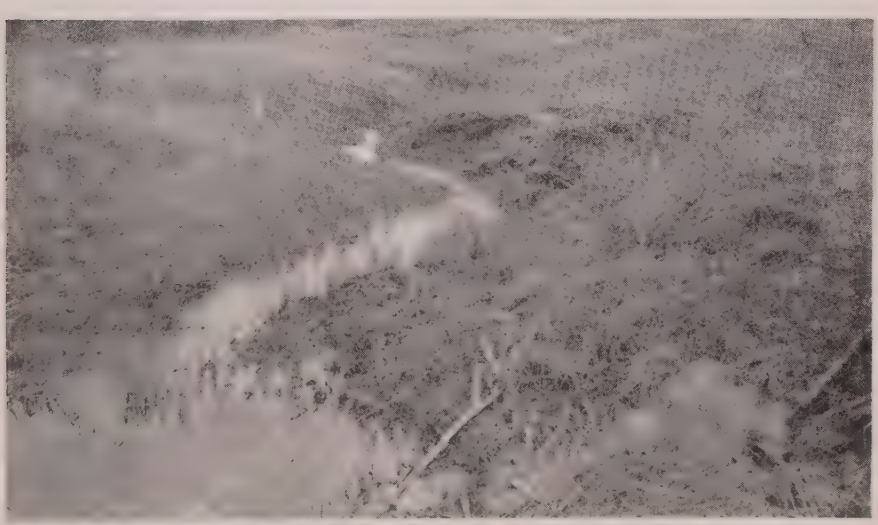

Fig. 3. Stream one mile north of College, Alaska, site of trap in which *Culicoides yukonensis* Hoffman were captured.

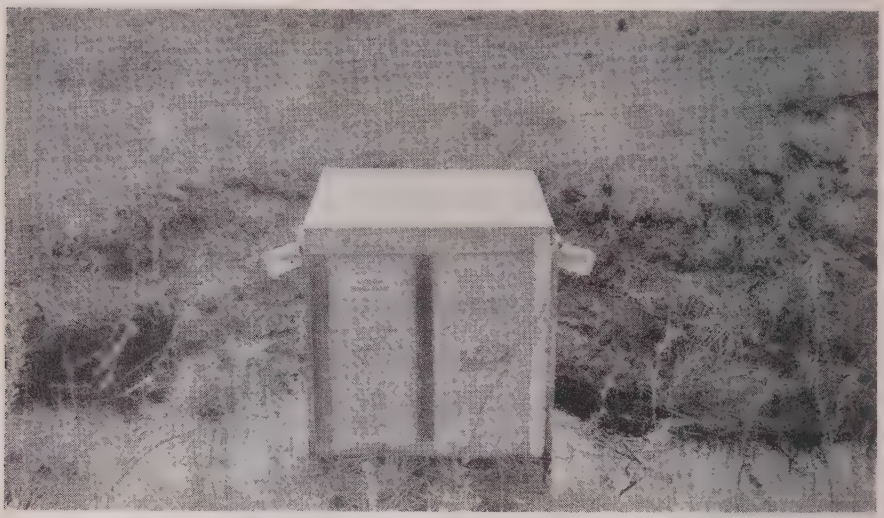

FIG. 4. Trap in which 89 adult *Culicoides yukonensis* Hoffman were captured. Photograph taken June 5, 1948. Stream level 3 inches higher than when *yukonensis* emerged.

following pH readings were taken: June 7, 7–; June 15, 7.5; July 1, 7–.

The stream was still frozen over on May 8, but by May 13 most of the ice was gone. Runoff did not subside until May 26. Thereafter the water level remained quite constant. Weekly temperature records from May 8 to September 15 ranged from 32° F. on May 8 to 75° F. on June 15. Average water temperature for the period of observation was 52.5° F.

Although most of the area under the trap was covered by moving water, a portion was near and, depending upon the water level, at times included, a segment of stream margin. The small number of adult females encountered in the area during July and August would support the conclusion that the breeding area in the vicinity of the stream must have been somewhat limited and perhaps was restricted to a very narrow band at the water's edge.

It is of interest to compare our observations with those of Frohne (1953), who studied *yukonensis* in the Cook Inlet area near Anchorage. He found that adults of both sexes emerged over a period of a month from (1) the saturated sphagnum mat bordering a bog lake, and (2) wet *Carex* marshes included within the bog. He added that his data did not exclude other similar "boggy" habitats.

The most striking difference between Frohne's data and ours concerns season of emergence. Frohne, using traps similar to ours, took a single male on July 15 at a *Carex* marsh location, but no additional specimens until July 31. Thereafter his trap counts increased daily until peak emergence was reached on August 9. Emergence fell off rapidly until August 13. Thereafter, only occasional females were taken until the last week of August when emergence ceased.

If the breeding site where our observations were made is typical of the Fairbanks area, *yukonensis* emerges in central Alaska more than a month earlier than it does in the Cook Inlet area. Adult activity observed at Fort Yukon during the first half of July in 1951 and 1953 virtually eliminates the possibility that our data represented an atypical situation.

Assuming that only one generation is involved and that the population of *yukon-*

ensis in central Alaska and that of the Cook Inlet area belong to the same species, we must look to the environment of the two regions for an explanation for the difference in season of emergence. It seems likely that the marked difference in the climate is responsible, for although "break-up" at Fairbanks may occur as much as a month later than at Anchorage, actually the season advances much more rapidly at Fairbanks. Summer temperatures at Fairbanks are much higher than at Anchorage and the days are also longer, thus speeding up both plant and animal development. Even so, it is surprising that emergence takes place more than 4 weeks later at Anchorage.

Species Known from Alaska. Sailer, Marks, Gregson, and Morris (1949) listed locality data for *Culicoides* collected by the Alaska Insect Project during 1948. Wirth (1951) published a paper on Alaskan *Culicoides* based in large part on the same material. From his paper it is evident that many of the records cited by Sailer *et al.* are erroneous. According to Wirth, *biguttatus* (Coquillett) is not known from Alaska, and previous records for this species have been based on poorly marked specimens of *obsoletus* (Meigen). Specimens from interior Alaska which Sailer *et al.* reported as *tristriatulus* were identified by Wirth as *cockerellii* (Coquillett).

Six species of *Culicoides* have been recorded as found in Alaska and are listed below, accompanied by a summary of the known distribution of each.

Culicoides obsoletus (Meigen). Jenkins (1948) reported *obsoletus* as the most abundant and widely distributed of the Alaskan *Culicoides*. Wirth, on the other hand, reported the species from only one inland locality. Present information indicates it to be one of the most common punkies in lowland areas of southeastern Alaska (Frohne and Sleeper 1951), northward along the coast to Cook Inlet. It is also known from as far north as 70 miles northeast of Fairbanks on the Steese Highway. Other records show the species to be widely distributed in central Alaska though it has not been collected in nearly so many localities nor in such large numbers as *yukonensis*.

Culicoides tristriatulus Hoffman. Sailer *et al.* (1949) recorded *tristriatulus* from three inland localities. These records conflicted with evidence that the immature stages lived in the intertidal zone of coastal marshes (Williams, 1951). Wirth (1951) was able to show that the inland records actually applied to *cockerellii*. The remaining published records show that *tristriatulus* is a common species along the coasts of Prince William Sound, Cook Inlet, and Kodiak Island. The species is known to be a serious pest at Valdez, where it is most numerous in late June through the first half of August.

Culicoides cockerellii (Coquillett). The four localities from which Wirth (1951) recorded *cockerellii* are all north of Copper Center between the Chugach and Alaska ranges. All records were made between August 29 and September 8. At one locality on the Glenn Highway (mile 137.5) the species was numerous enough to cause the survey party considerable annoyance during the few minutes spent there at about 4:30 p.m. on September 7.

Culicoides yukonensis Hoffman. This species has been recorded from Haines northward to Fort Yukon. Most records are from areas where lowland muskeg is prevalent; however, one specimen was captured at an elevation of 3000 feet in the Chugach Range near Anchorage. The species appears to be the most common punkie north of the coastal ranges and is probably found throughout the tree zone of central Alaska. Earliest seasonal records are the Fairbanks emergence trap captures between June 19 and July 2. Present records show the species to be most numerous between mid-July and mid-September. Frohne (1953) found adult emergence in the Cook Inlet area to take place more than a month later than the emergence we observed at Fairbanks.

In mid-July of 1951 *yukonensis* was causing the inhabitants of Fort Yukon serious annoyance. Fort Yukon was visited again during the first week of July in 1953. The species was much less num-

erous than in 1951, and it is quite possible that emergence in the area was not complete.

Culicoides alaskensis Wirth. *Culicoides alaskensis* is known from Valdez, Anchorage (Wirth, 1951), and Fortuna Ledge (Berg, 1953). All collections were made between July 9 and August 15. Nowhere does the species appear to be common.

Culicoides unicolor (Coquillett). Wirth (1951) recorded *unicolor* from four southeastern coastal localities and from Fairbanks. The Fairbanks record was based on two specimens captured in the emergence trap mentioned in the discussion of *yukonensis*. Wirth noted that these two specimens differed noticeably from those taken at Valdez. In view of the marked difference between the environment of southeastern Alaska and that of Fairbanks, it is likely that the Fairbanks specimens actually represent a different species. The earliest seasonal record for *unicolor* is June 19 and the latest, July 30.

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EFFECTS OF DROUGHT ON THE COMPOSITION OF RURAL MOSQUITO POPULATIONS AS REFLECTED BY LIGHT TRAP CATCHES

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Introduction. Adult mosquito collections are made routinely in Baker County, Georgia, as part of a study of the ecology of mosquito vectors of diseases being conducted at the Newton Field Station. Prior to 1952, collections were made irregularly and were concerned primarily with the occurrence and abundance of *Anopheles* spp. Since 1952, collections have been made at weekly intervals and have been directed toward the collecting of a complete sample of the mosquito fauna. Fortunately a sufficient number of collections were made at the same locations during the two periods to permit some comparisons of species composition. The data contained in the present report compare catches during a year of normal precipitation with catches from the same locations following several successive dry years. The purpose of the note is to indicate the extent to which this species composition may vary within a comparatively few years and hence the obvious implications regarding the prevalence of diseases carried by particular species.

Methods. Records from New Jersey type light traps situated near two breeding areas which are of a permanent type in years of normal rainfall were utilized in making these comparisons. Since only anopheline mosquitoes were studied intensively at the Newton Field Station prior to 1952, continuous records on culicine mosquitoes from these locations are available only for the months of August, September, and October for one year of normal rainfall, 1942. This particular year was fairly typical of those centrally located within a period of years with normal precipitation (approximately 56 inches), as a total of 61.46 inches was recorded according to official U. S. Weather Bureau records for Hoggard's Mill (Emory University Field Station), Georgia. The total rainfall for the months considered measured 6.64 inches, 5.51 inches, and 1.17 inches respectively. The recent year chosen for comparison was 1955, the sixth in a series of so-called drought years (1949–44.4 inches, 1950–46.2, 1951–40.8, 1952–42.7, 1953–58.8, 1954–27.1, 1955–39.6). The slightly greater than normal rainfall in 1953 failed to relieve the drought conditions. Rainfall for August, September, and October 1955 was 2.36 inches, 2.65 inches, and 3.65 inches.

Comparisons were made between the mosquito species known to breed chiefly in permanent ponds and those known to breed in temporary water. The species of mosquitoes considered to be permanent pool breeders are *Anopheles quadrimaculatus, A. crucians, A. punctipennis, Culex territans, C. erraticus, Mansonia perturbans,* and *Uranotaenia sapphirina.* All 13 species of *Aedes* and *Psorphora* which occur in the area were considered to be temporary or intermittent pool breeders. Other species caught in the light traps were omitted from the tabulations of permanent versus temporary pool studies (tables 1 and 2) since they were chiefly *Culex* (*Melanoconion*) spp. females which could not be assigned to either category.

The 1942 records presented are based upon a small number of collections (2) in August, and representative numbers of collections in September (11) and October (22) made from a single light trap at the 6-foot level in each of the two locations. The 1955 records are based upon catches from the same locations; a single trap at 6-foot height being used for one location

and the combined catches from three traps at the 6-, 25-, and 40-foot levels being used at the other location.

In the area where a single light trap was operated under similar conditions during August, September, and October of both 1942 and 1955, total numbers of mosquitoes caught were compared. Monthly averages and an average number of mosquitoes per trap night during the study period were computed (table 3).

TABLE 1.—Number of nights light traps operated, and numbers and percentages of permanent pool mosquitoes caught during August, September, and October of 1942 and 1955: Baker County, Georgia

	1942	1955
Number nights traps operated	35	27
Anopheles spp.		
Number specimens caught	789	78
Percent of permanent pool mosquitoes	17.8	44.3
Percent of total catch	17.4	1.0
Uranotaenia sapphirina		
Number specimens caught	3,615	95
Percent of permanent pool mosquitoes	81.6	54.0
Percent of total catch	80.0	1.2
Other Permanent Pool Mosquitoes		
Number specimens caught	24	3
Percent of permanent pool mosquitoes	0.6	1.7
Percent of total catch	0.5	0.04
Total number permanent pool mosquitoes	4,428	176
Percent of total catch	98.2	2.2

TABLE 2.—Numbers and percentages of temporary pool mosquitoes caught in light traps during August, September, and October of 1942 and 1955: Baker County, Georgia

	1942	1955
Aedes spp.		
Number specimens caught	55	7,712
Percent of temporary pool mosquitoes	66.3	96.7
Percent of total catch	1.2	94.6
Psorophora spp.		
Number specimens caught	28	269
Percent of temporary pool mosquitoes	33.7	3.4
Percent of total catch	0.6	3.3
Total number temporary pool mosquitoes	83	7,973
Percent of total catch	1.8	97.8

TABLE 3.—Numbers of mosquitoes caught in light traps at Springfield Pond, Baker County, Georgia, in August, September, and October 1942 and 1955

	Aug.	Sept.	Oct.	Total
	1942			
Number nights traps operated	2	10	11	23
Total number mosquitoes	54	321	98	473
Average number per trap night	27.0	32.1	8.9	20.6
	1955			
Number nights traps operated	5	4	4	13
Total number mosquitoes	677	572	164	1,413
Average number per trap night	135.4	143.0	41.0	108.7

RESULTS. In table 1, it is notable that the *Anopheles* spp. (chiefly *crucians* and *quadrimaculatus*) and *U. sapphirina* composed more than 98 percent of the permanent pool mosquitoes, while *Culex territans* and *C. erraticus,* the other permanent pool mosquitoes, composed less than 2 percent of the catch in either of the years considered. In the year of normal rainfall, 1942, *U. sapphirina* greatly exceeded the *Anopheles* (81.6 percent to 17.8 percent), while in the drought year it exceeded *Anopheles* spp. by only a little less than 10 percent. Totals for the three months indicate that in a normal year catches of permanent pond mosquitoes constituted 08.2 percent of the total mosquitoes, while in the drought year they constituted only 2.2 percent of the catch.

The *Aedes* spp. are shown by table 2 to comprise more than nine-tenths of the light trap catch of intermittent pool mosquitoes taken during the three months of the drought year. In a normal year, they exceeded the *Psorophora* spp. by approxi-

mately 33 percent. The intermittent pool mosquitoes constituted only 1.8 percent of the total mosquito catch in the normal year, and 97.8 percent during the drought year. There was an almost complete reversal in the composition of the light trap catches with reference to the species which breed in permanent and temporary situations.

Monthly averages of total mosquitoes caught per trap night during the three-month period of 1942 and 1955 are shown in table 3. It is to be noted that slightly more than four times as many mosquitoes were attracted to the light traps during the drought year as in the normal year, and that this proportion remained relatively stable from month to month in the study period.

DISCUSSION. Six successive drought years in rural southwestern Georgia, 1949 through 1955, have changed the numerous permanent and lime-sink ponds successively into intermittent and temporary pools, then into dry basins covered by sparse annual vegetation and organic remains of aquatic plants. The composition of the mosquito fauna of the region has changed to adapt itself to these drought conditions. The data presented indicate that the chief species concerned in this change in the area studied are *Anopheles* spp. and *Urantaenia sapphirina* which are dominant in years of normal rainfall, and *Aedes* spp. and *Psorophora* spp. which comprise most of the light trap catches in a drought year.

It is a common belief that a succession of dry years greatly reduces mosquito populations. This hypothesis has been refuted by data presented here. It is demonstrated in table 3 that many more mosquitoes may be caught in light traps at the same location during a drought year than in a year of normal rainfall. It is true that great changes take place in the abundance of the mosquito species which compose the population of a region, the species most favored by environmental changes becoming most abundant. Since the mosquito species vary greatly in their ability to act as reservoirs and to transmit diseases of man and other animals, and to affect the general health of the human population by their activities, it is expedient that the effects of the most common environmental factors upon their abundance and distribution be investigated and understood.

SUMMARY. A comparison of light trap catches of mosquitoes was made from the vicinity of two permanent pool environments in rural southwestern Georgia during the months of August, September, and October in a year of normal rainfall (1942) and a year of drought (1955). An almost complete reversal of species composition was noted. Anopheline species, chiefly *A. quadrimaculatus* and *A. crucians,* and *Uranotaenia sapphirina* composed 98.2 percent of the catch in the normal year, while in the drought year *Aedes* and *Psorophora* species, chiefly *A. vexans,* composed 97.8 percent of the light trap catches considered.

Approximately 80 percent more mosquitoes were taken per night of light trapping during the drought year than in the normal year.

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A PRELIMINARY REPORT ON THE LABORATORY COLONIZATION OF THE MOSQUITO *CULEX TRITAENIORHYNCHUS* GILES [1]

H. D. NEWSON, T. E. BLAKESLEE, S. TOSHIOKA, M. SAKAI, C. M. WHEELER, T. SHIMADA AND J. AKIYAMA

INTRODUCTION. The mosquito *Culex tritaeniorhynchus* is considered to be the principal vector of Japanese B encephalitis in Japan. One of the limiting factors in the study of this disease has been the lack of a laboratory colony of this mosquito.

A method developed during the summer of 1956 and now in use at the 406th Medical General Laboratory, has resulted in the successful rearing of this species through an estimated 6 generations. Mortality in all stages is low, the adults are large and vigorous and the colony is flourishing. Over 15,000 egg rafts were produced between June 22, when the first two rafts were collected, and October 22. During the first three weeks of October an average of over 400 egg rafts per day were produced, of which approximately 95 percent contained viable eggs. The 406th Medical General Laboratory Strain is a mixture started with larvae from Okinawa and Kyushu, Japan and eggs from the vicinity of Tokyo, Japan.

CAGE. The rearing cage, which is located in a corner of the insectary, is approximately 11 feet long, 8 feet wide and 8 feet high.

ADULTS. Cotton wads soaked in a 2 percent sugar solution, and fresh apple slices are provided daily. Two rabbits and a pig are maintained in the cage each night and a rabbit is kept in the cage during the day. The females feed equally well on either the rabbit or the pig, and although some blood meals are taken throughout the day, most females feed at night.

The temperature is maintained at approximately 75° F. and the relative humidity between 80 percent and 95 percent.

Both natural and artificial light are used. Natural light enters through three windows. Artificial light is provided by fluorescent ceiling lights and a rheostat controlled lamp located just outside the cage into which light is reflected by a metal sheet. The light schedule simulates the dawn and dusk light intensities recorded in the center of the cage during July and August. It consists of a dawn period of 1 hour, a day period of 12½ hours, a dusk period of 1½ hours and a night period of 9 hours. Peak mating occurs when the light intensity in the center of the cage is less than one foot candle.

EGGS. Most oviposition occurs during darkness, although a few rafts are deposited during the day. Females usually oviposit in the larval rearing tubs but occasionally oviposit on water puddles on the floor. Hatching occurs within 48 hours.

LARVAE. Larvae are reared in tap water containing food pellets of high protein content. The medium, which is contained in tubs 18 inches in diameter and 8 inches deep, is aerated by bubbling compressed air through it. Approximately 2,500 larvae can be successfully reared in a tub of this size. The duration of the larval stage averages 6 days.

PUPAE. Pupation, which requires about 2 days, occurs in the larval medium and the adults emerge directly into the cage.

SUMMARY. A colony of *Culex tritaeniorhynchus* has been successfully reared through an estimated 6 generations in the laboratory. The colony is housed in a cage 11 feet long, 8 feet wide and 8 feet high. Temperature is maintained at

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75° F. and the relative humidity from 80–95 percent. A light schedule is used that simulates the dawn and dusk lighting conditions produced in the cage during July and August and provides a total daylight period of over 12 hours. Sucrose, fresh apple slices, a pig and rabbits are provided as food for adults. Larvae are reared in aerated tap water containing high protein food pellets.

EGG FORMATION AND OVIPOSITION IN BLOOD-FED *AEDES AEGYPTI* L.

ROBERT C. WALLIS [1] AND CALVIN A. LANG [1, 2]

Investigation of the blood meal factor which is required by adult female mosquitoes for egg production necessitates the development of a suitable assay to evaluate test diets. Some of the conditions of such an assay have been studied, and it was noted that maximal egg deposition was related to mating. Such a relationship has been discussed by several investigators (MacGregor, 1931; Mellanby and Mellanby, 1937) but the recent studies of Gillett (1955) demonstrated this with a strain of *Aedes aegypti*. From more recent studies, Lang (1956) suggested that the blood meal is the primary stimulus for egg formation, whereas mating is concerned chiefly with oviposition. The results of further experimentation to elucidate these interrelationships are presented here.

Experimental Procedure. Larvae of *Aedes aegypti* were reared on a commercial feed medium in enameled pans. Males and females were separated in the pupal stage. Adults were divided into two groups: one contained only virgin females, and the other contained females plus an excess number of males. Both groups of mosquitoes were maintained on a 10 percent sucrose solution for the remainder of the experiment. After 7 to 10 days from emergence, the mosquitoes were deprived of food and water for approximately 20 hours and then offered a blood meal from the forearm of a human host. Following this meal, engorged females from each test group were transferred to individual test cages, and two males were added to the cage of each "mated" female. The control series of both virgin and mated females was maintained on sucrose solution alone. For the next 14 days of the experimental period the cages were kept in a humid condition (greater than 70 percent R. H.) at a temperature of 23–25° C. Cages were examined daily, and the oviposition time of each female was noted. This experiment, which included a total number of 128 virgin and 46 mated females, was replicated 4 times.

In the first three experimental series each female was dissected on the 14th day post-blood meal and examined microscopically after oviposition to ascertain the number of eggs retained in the abdomen. In addition, every mated female was examined to determine the presence of sperm in the spermathecae.

To obtain information on ovarian development and egg formation, a series of mosquitoes from all groups were dissected at daily intervals from the time of emergence through a four-day period following engorgement.

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RESULTS. Of a total number of 128 virgin females, 55 percent deposited eggs within seven days of the blood feeding. Of the 46 mated females, 89 percent oviposited during the same period. The average number of eggs from females in each group is shown in Table 1. The eggs per female ratios based on the observed data were significantly less than those ratios of corrected data in which the females laying less than 20 eggs or retaining eggs were excluded in the calculation.

A large percentage of mosquitoes retained eggs after 14 days as shown in Table 2. The incidence of retention in the virgin group was approximately three times greater than in the mated females.

Of these females retaining eggs, the number retained was compared with the number oviposited (Table 3). The sum of these two counts provided an index of the number formed. The 25 virgins oviposited an average of 26 eggs per female and retained an additional 56 eggs per female. Therefore, 31 percent of the total eggs formed were deposited and 69 percent were retained. The three mated females oviposited 20 percent and retained 80 percent of the total eggs formed.

Spermatozoa were observed in the dissected spermathecae of all but four of the 46 mated females.

Daily examination of ovaries dissected between the time of emergence and oviposition revealed marked changes in ovarian size and development. Up to the time of the blood meal, the ovaries of all females progressed to a stage of development similar to Christopher's Stage 2, which was characterized by the appearance of spherical, transparent follicles. No further development was observed in any of the mosquitoes which engorged only on sucrose. In the blood-fed females, however, rapid ovarian changes occurred on the second and third day post blood meal, resulting in a stage similar to Christopher's Stage 4 or 5. During this period the follicles became elongated and filled with dense, opaque granules. A clear polar region was apparent at one end. By the 4th post blood meal day the eggs appeared ready for oviposition. The only difference observed between the fed mated and virgin females was a slight delay in development of the latter through the second day following the blood meal. There appeared to be a greater variation in ovarian development among the blood-fed virgins in contrast to the uniform response in the mated group.

DISCUSSION. In studies of nutritional factors in the blood meal which stimulate ovarian activity and subsequent egg formation, the criterion commonly used for evaluation of the potency of test diets has been the number of eggs laid per female after the mosquito has engorged on a test fluid. Such an index is based on the assumption that only the blood meal is important in the subsequent oviposition response. However, recent evidence indicates that other factors influence oviposition (Woke, 1955) so that an egg count may not be an accurate indication of the nutritional potency of the meal.

Gillett (1955) has reported that one strain of *Aedes aegypti* failed to lay eggs unless mating took place. Furthermore, in a recent report, Lang (1956) indicated that there was a difference in the number of eggs oviposited by mated and virgin *Aedes aegypti*. The question arose as to whether mating played a role in stimulating egg formation or affected only the oviposition response.

The results presented here confirmed the previous finding that the oviposition time of virgin females is longer and more variable than that of mated females. In addition, a higher percentage of the virgins retained eggs, and in these individuals the number of eggs retained was sizable—amounting to approximately 70 percent of the number of eggs formed—despite the fact that they developed more eggs than mated females.

While mating affected the number of eggs deposited, and to some extent the number developed in the female, dissection of individual specimens at 24-hour intervals during the experimental period

TABLE 1.—Egg deposition by *Aedes aegypti* 14 days post blood meal

	Virgin			Mated		
		Eggs/Female			Eggs/Female	
Experiment	Number	Observed	Corrected*	Number	Observed	Corrected*
1	88	68.5	87.7	31	54.6	73.6
2	40	56.9	72.9	15	57.7	65.2
Combined	128	64.9	83.1	46	55.6	70.5

* Corrected values exclude those females laying less than 20 eggs or retaining eggs.

TABLE 2.—Number of *Aedes aegypti* retaining eggs 14 days post blood meal

Replicate	Total Number	Number Retaining	Total Number	Number Retaining
1	29	5	10	0
2	30	12	11	2
3	29	8	10	1
Combined	88	25	31	3

TABLE 3.—Egg formation by *Aedes aegypti* retaining eggs

	Virgin				Mated			
		Eggs/Female				Eggs/Female		
Replicate	Number	Oviposited	Retained	Formed	Number	Oviposited	Retained	Formed
1	5	19.6	50.5	70.2	0	....	....	....
2	12	25.5	63.3	88.8	2	17.0	46.0	63.0
3	8	30.3	48.8	79.0	1	0	53.0	53.0
Combined	25	25.8	56.1	82.0	3	11.3	48.3	59.7

revealed little influence of mating on ovarian development. Rapid changes took place within three days post blood meal in individuals of both the virgin and mated groups. In comparison, no such stimulation of activity appeared in females engorged only on sucrose. It is possible, therefore, to evaluate a test diet by examination of dissected ovaries two to three days after administration of the test preparation. This provides a rapid assay devoid of the variation associated with the oviposition response.

Clements (1956) concluded that gonadotrophic hormone from the corpora allata is not responsible for the stimulation of rapid ovarian development. He summarized his discussion thus:

"It seems unlikely that, where ovary development takes place despite ligation within a very few minutes of the start of feeding, suffiicent hormone can pass into the abdomen. If hormones are secreted before feeding takes place, some chemical factor in the food or some behavioural stimulus from feeding may trigger ovary growth."

In the experimental series of females which engorged on sucrose solution alone, dissection and examination of the ovaries at daily intervals revealed no stimulation of ovarian activity, so that it seems un-

likely that a behavioural stimulus such as abdominal distension following feeding is involved. Rather, it is suggested that stimulation is associated with a chemical factor in the blood meal, and further work is essential for the identification of this factor.

SUMMARY. Laboratory experiments were conducted using blood-fed virgin and mated *Aedes aegypti* to determine the effect of mating on ovarian development and oviposition. The average oviposition time of the virgin females was considerably greater than that of the mated ones. Furthermore, the oviposition time of the virgins was variable compared to a relatively uniform response of the mated females. The average number of eggs per female in both groups was increased significantly by excluding from the calculation those females which retained or laid few eggs. Females retaining eggs deposited only 20–30 percent of their total eggs formed. In both virgin and mated females ovarian development was arrested at Christopher Stage 2 unless a blood meal was ingested. Therefore, mating affects the oviposition response but has little effect on ovarian development and egg formation. Abdominal distension from engorgement with sucrose solution failed to stimulate development comparable to that following engorgement with blood. Dissection and examination of the ovaries of blood-fed females two to three days post blood feeding provides a rapid assay for the presence of an ovarian stimulating factor in an experimental preparation.

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VARIATION OF STRUCTURES OF TAXONOMIC SIGNIFICANCE IN FOURTH INSTAR *CULEX TARSALIS* Coq. LARVAE

JOHN M. WHITE [1]

Published descriptions of the fourth instar larvae of *Culex tarsalis* usually state that the upper and lower head hairs are multiple. The siphon, according to Dyar (1928), is slender, uniform, and about four times longer than wide; five paired tufts are inserted irregularly on the siphon, the basal one within the pecten, none are displaced, nor is the subapical one moved laterally. Yates (1943), in a study of fourth instar *Culex tarsalis* larvae observed considerable variation in several of the features mentioned above.

In the present investigation, 542 fourth instar *Culex tarsalis* larvae collected from various habitats in northern, southern, eastern, and western Texas were examined for structural variations and compared with 151 fourth instar *Culex tarsalis* larvae reared in the laboratory from five isolated egg rafts. Three of the egg rafts were collected in Palmetto State Park, Texas and two were collected near Austin, Texas. The following variations were observed.

The upper head hairs of all larvae were examined to determine the maximum and minimum number of branches present. Of the group of 542 larvae, these hairs varied from two to eight branches. In the group of 151 laboratory reared specimens, the number of branches varied from two to six.

A more detailed analysis of the variations in the number of branches of the lower head hairs was made. The results are summarized in Table 1.

As previously mentioned, many important diagnostic features identifying fourth instar larvae as *Culex tarsalis* are associated with the siphon and its component structures. Consequently, in this study emphasis was placed on examining the siphons of both the larvae collected in the field and those reared in the laboratory from isolated egg rafts. Variations observed are recorded in following tables.

The data in the tables 1 through 4 indicate that a wide range of variation of similar anatomical structures may occur in the fourth instar *Culex tarsalis* larvae from different localities and even among larvae reared from the same egg raft. The possibility of the occurrence of such variations should be borne in mind when iden-

TABLE 1.—Variation in number of branches of lower head hairs of 4th instar larvae of *C. tarsalis*

	Group I 542 Fourth Instars Collected in Field	Group II 151 Fourth Instars Reared in Laboratory
Variation in number of branches of lower head hairs	2 to 6 branches	2 to 5 branches
	No. of Specimens	No. of Specimens
Both lower head hairs with same no. of branches	358	67
Lower head hairs with different no. of branches	184	84
Both lower head hairs with five or more branches	39	0
Both lower head hairs with four branches	166	42
Both lower head hairs with three branches	153	25
Total	542	151

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TABLE 2.—Alignment of subventral tufts along ventral margin of siphon of 4th instar larvae of *C. tarsalis*

	Group I 542 Fourth Instars Collected in Field No. of Specimens	Group II 151 Fourth Instars Reared in Laboratory No. of Specimens
All tufts in straight line	221	67
Distal tuft displaced slightly laterad	96	24
Subapical tuft displaced slightly laterad	20	16
Distal and subapical tufts displaced slightly laterad	202	44
Three more distal tufts displaced slightly laterad	3	0
Total	542	151

TABLE 3.—Insertion of subventral tufts on siphon of 4th instar larvae of *C. tarsalis*

	Group I 542 Fourth Instars Collected in Field No. of Specimens	Group II 151 Fourth Instars Reared in Laboratory No. of Specimens
Proximal subventral tuft proximal to distal pecten tooth	62	9
Proximal subventral tuft inserted near distal pecten tooth but not proximal to it	469	140
Proximal subventral tuft inserted near center of siphon	11	2
Total	542	151

TABLE 4.—Number of subventral tufts on siphon of 4th instar larvae of *C. tarsalis*

	Group I 542 Fourth Instars Collected in Field No. of Specimens	Group II 151 Fourth Instars Reared in Laboratory No. of Specimens
Three pairs of tufts	2	0
Four pairs of tufts	12	10
Five pairs of tufts	449	135
Six pairs of tufts	78	6
Seven pairs of tufts	1	0
Total	542	151

tifying fourth instar *Culex tarsalis* larvae; otherwise, incorrect determinations may result.

ACKNOWLEDGMENT. The writer is deeply indebted to Dr. O. P. Breland of the University of Texas for his most helpful suggestions during the course of this investigation.

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INSEMINATION RATES AND EGG DEVELOPMENT OF FEMALE *CULEX TRITAENIORHYNCHUS* IN NATURE[1]

T. E. BLAKESLEE,[5] H. D. NEWSON,[2] M. SAKAI,[3] AND S. TOSHIOKA[4]

Attempts to establish a laboratory colony of *Culex tritaeniorhynchus* at the 406th Medical General Laboratory, Tokyo, have not yet succeeded. Suitable techniques have been developed to rear and maintain this species, but attempts to obtain consistent mating and egg production in the laboratory have not been successful (1, 2, 3). Adults reared from field-collected larvae and eggs have been subjected to a wide variety of combinations of humidity, temperature and light intensities, in an effort to provide conditions which were suitable for mating. The insemination rate in females varied according to the conditions to which they had been subjected, but never exceeded 5 percent and, usually, was much less. Few egg rafts were produced in the laboratory and only 7 percent of over 2,000 laboratory reared females examined showed any egg development. To obtain data with which these laboratory observations could be compared, a field study was made in 1955 to determine the insemination rate and egg development of *C. tritaeniorhynchus* females in nature.

Materials and Methods. The study was started on August 12 and continued through September 27 when specimens no longer could be found in the study area. Collections were made six times each week through September 5 and daily thereafter. Adult females were collected with a light trap and from a cow barn located in a rural area approximately 25 miles northwest of Tokyo, Japan. The barn was located in the center of a small village. The light trap was operated approximately four feet above the ground near a group of nightsoil tanks at the edge of the village, approximately 100 yards from the barn. During the study, these tanks were a principal breeding site for the *Culex tritaeniorhynchus* in this area.

Results. A total of 1842 female *C. tritaeniorhynchus* were collected and examined for insemination and egg development. The average insemination rates, by week, for the light trap and cow barn collections are shown in Fig. 1. Total collections from the light trap had approximately the same proportion of inseminated females as those from the cow barn. Except for the decrease during the week of September 2 to 8, the average rate of insemination for all specimens steadily increased from 93 percent during the first week of the study to 100 percent during the week of September 9 to 15. Only one specimen collected after September 9 was not inseminated. The decrease during the week of September 2 to 8 was caused by decreased rates in the cow barn collections of September 3 and 5 and in the light trap collection made on the night of September 5–6. Insemination rates in the cow barn collections on September 3 and 5 were 44 and 61 percent respectively, and 86 percent in the light trap collection on the night of September 5–6. Heavy rains on September 1 and 2 perhaps were contributing factors to these decreased rates. Except for these three collections, 99 percent of the females collected that week were inseminated.

For the purpose of this study the ovulation cycle of *C. tritaeniorhynchus* was arbitrarily divided into four stages: 1. No egg development; 2. Enlargement of fol-

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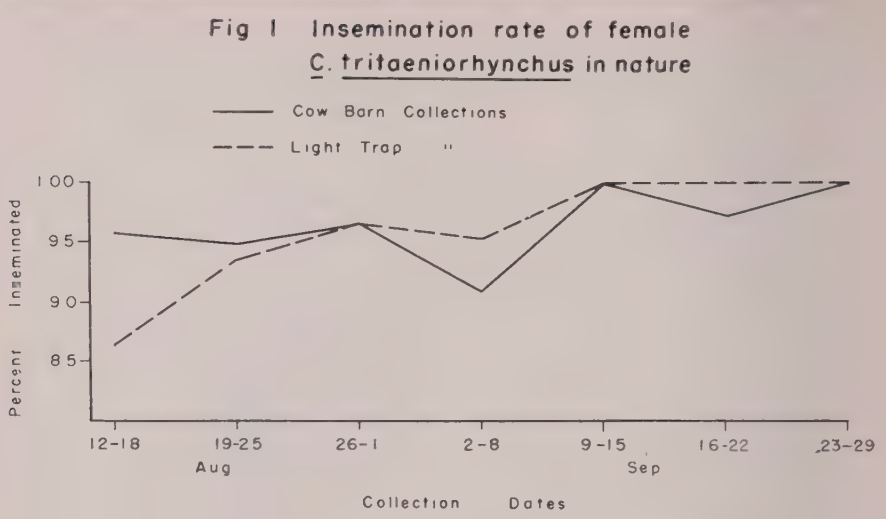

licle, yolk not present; 3. Follicle further enlarged, yolk present; 4. Mature eggs. The percentage of the collections, by week, in each of these stages is shown in Table 1. The proportion of females in each stage of egg development varied erratically from week to week throughout the study. Slightly over one-third of the collections from both the light trap and cow barn were in stage 1 of the ovulation cycle. Light trap and cow barn collections differed markedly, however, in the proportion of females in the other three stages. Over one-half of those collected in the cow

TABLE 1.—Egg development of *Culex tritaeniorhynchus* females in nature

	Percent in each Stage of Development							
	Stage 1		Stage 2		Stage 3		Stage 4	
	No Egg Development		Follicle Slightly Enlarged, No Yolk Present		Follicle Further Enlarged, Yolk Developed		Mature Egg	
Collection Period	Cow Barn	Light Trap	Cow Barn	Light Trap	Cow Barn	Light Trap	Cow Barn	Light Trap
Aug. 12–18	69	62	28	3	2	13	1	22
Aug. 19–25	14	55	83	10	3	33	<1	2
Aug. 26–Sept. 1	32	18	59	4	9	59	<1	19
Sept. 2–8	41	9	58	6	0	77	1	8
Sept. 9–15	32	37	68	0	0	63	<1	0
Sept. 16–22	51	25	49	0	0	75	0	0
Sept. 23–29	50	14	25	14	25	29	0	43
Percent for total period	37	39	59	5	4	44	<1	12
Total number Examined	500	193	786	27	54	217	6	59

barn were in stage 2 and less than 5 percent were in stages 3 and 4. Only slightly more than 5 percent of the females from the light trap collections were in stage 2 while 56 percent were in stages 3 and 4. Sixty-two percent of the 1842 females collected in this study had some egg development.

Of 65 females which contained fully developed eggs when collected, three did not have sperm in their spermathecae. In each of these three the eggs were normal in size and appearance.

Summary. A field study was made to compare the insemination rate and egg development of *Culex tritaeniorhynchus* females in nature with those maintained in the laboratory. The insemination rate in laboratory females varied from 0 to 5 percent depending upon the conditions to which they had been subjected. Ninety-seven percent of the females collected in nature during a study period of seven weeks had been inseminated. There was a gradual rise in the rate from 93 percent in those collected during the first week to 100 percent in those collected in the fifth week. Only one female collected after the fourth week had not been inseminated. Seven percent of the laboratory reared females had some egg development as compared with 62 percent of those collected in the field. Approximately one-third of the light trap and cow barn collections had no egg development. Egg development, when present, was usually more advanced in females collected in the light trap than those collected in the cow barn.

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CONTROL OF MOSQUITOES FOUND IN LOG PONDS IN WESTERN OREGON

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Several species of pest mosquitoes are known to breed in the log ponds of western Oregon. Since the lumber industry has undergone considerable expansion in recent years, the number of log ponds and the acreage involved have also increased. In 1940, 442 mills were in operation in the 19 western counties while in 1947 there were 1295. This change has obviously increased the mosquito potential of the region.

The predominating species in the log ponds are *Culex tarsalis* Coq., *C. stigmatosoma* Dyar, and *Culiseta incidens* (Thompson). *Culex pipiens* (L), *C. territans* (Walk.), and *Anopheles punctipennis* (Say) are found in lesser numbers. Normally, the ponds support larvae from May through September. A seasonal species trend apparently exists, at least in the Corvallis area, in which *tarsalis* and *incidens* predominate in the spring and early summer but *stigmatosoma* is more prevalent in the late summer and fall.

Several experiments on the control of mosquitoes breeding in log ponds have

[1] Retired November 1952.

TABLE 1.—Control of mosquito larvae in log ponds with DDT in various formulations and dosages

Plot No.	Rate of Treatment: Pounds Per Acre	Rate of Treatment: P.P.M.	Per Cent Mortality after 48 hours	Remarks
	50% W.P.			
4	1.6	0.2	75	Heavy infestation in 14 days.
5	1.5	.1	0	No control.
	5% in oil			
8	0.3	.0167	100	Larvae again in 14 days, many in 30 days.
12	.5	.0336	90	Heavy infestation in 18 days.
3	.5	.0335	90	Heavy infestation in 12 days.
	25% Emul. conc.			
10	0.6	.04	100	Light infestation 18 days, heavy in 30.
1	1.6	.1	100	Protection 30 days or more, infested in 48 days.
2	3.6	.1	100	Light infestation at 30 days, heavy in 48 days.
11	3.4	.2	100	No infestation at 18 days, but heavy in 30.
6	6.1	.2	100	Light infestation at 30 days, heavy in 48.
13	4.4	.2	95	No larvae after 30 or more days.

been conducted by the authors during the last few years. Most of them were with DDT and EPN and were directed toward determining (1) the amount of toxicant required, (2) the most effective formulation, and (3) the length of time a single application would remain effective.

All the test ponds were less than 5 acres in size, and averaged approximately 6 to 7 feet in depth. In the spring season (May and June) water temperatures were between 55° and 60° F.; in September they varied from 62° to 68° F.

A trombone-type hand sprayer was used for all applications. The insecticide concentrate was diluted with water obtained from the intake of the pond being treated and applied at a rate of 1 gallon per acre. In one series of tests (table 1) the toxicant was applied on a parts per million basis after computation of the volume of the pond, and in another (table 2) on a surface-acreage basis as might be in a practical control operation.

Percent control was established from the difference in the average number of larvae recorded in at least 20 dips per pond prior to and 24 and 48 hours after treatment. Only the 48-hour records are presented, but kill was similar at both intervals in most tests.

High initial reduction of larvae of *Culex tarsalis* and *Culiseta incidens* mosquitoes was demonstrated with DDT emulsions at rates of 0.04 to 0.2 p.p.m. and practical control through approximately 30 days at

TABLE 2.—Per cent mortality of mosquito larvae in log ponds 48 hours after treatment with DDT and EPN. 3 applications

Pounds per acre	Emulsion: EPN	Emulsion: DDT	Wettable Powder: EPN	Wettable Powder: DDT
0.0125	76	—	—	—
.025	89	—	—	—
.05	98	86	47	—
.075	99	95	95	—
.1	97	99	96	65
.25	100	100	—	83

0.1 and 0.2 p.p.m. Wettable-powder treatments of DDT were much less effective. Surface oils provided a good initial kill but reinfestation occurred more rapidly than with the emulsions.

On a surface-application basis complete control of *Culex tarsalis, C. pipiens,* and *Culiseta incidens* mosquitoes was obtained with as little as 0.25 pound of DDT or EPN in an emulsion per acre. However, this dosage probably represents the minimum and would no doubt be too low for general practical application, as reinfestation of the ponds was evident within 2 weeks.

When the results with the EPN and DDT emulsions are compared on a basis of 100 percent mortality, no difference in effectiveness is evident. At 0.025 pound of EPN per acre a mortality close to that caused by 0.05 pound of DDT was obtained. These figures do not demonstrate the difference between the two insecticides reported by Yates and Lindquist (1952) and Gjullin *et al.* (1953). Those workers showed that EPN was considerably more effective than DDT.

Because of these seemingly poor results with EPN, a series of laboratory tests was conducted relative to possible variations of effectiveness of either insecticide due to physical or chemical conditions of log pond water and to water temperature within the range of 60° to 80° F. The materials were tested at various dilutions in both tap and pond water against a mixture of *Culex tarsalis* (65%), *C. pipiens* (25%), and *Culiseta incidens* (10%) mosquitoes. The results (table 3) suggest a negative temperature coefficient for DDT in either medium and a slight positive temperature coefficient for EPN in tap water but no difference in pond water. Some apparent reduction of effectiveness in log pond water was indicated, possibly due to the suspended matter present or to an unidentified chemical condition.

TABLE 3.—Per cent mortality of mosquito larvae 48 hours after treatment with DDT or EPN in the laboratory

	At 80° F.		At 60°–70° F.	
P.P.M.	Tap Water	Pond Water	Tap Water	Pond Water
DDT				
0.00167	17	5	56	48
.0025	58	35	91	87
.005	96	—	100	95
.01	85	85	100	100
.02	98	97	100	—
.04	100	—	—	—
EPN				
0.000667	45	—	44	—
.001	82	58	69	51
.00125	93	67	79	59
.00167	99	73	82	78
.0025	—	—	85	78

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OBSERVATIONS ON *ANOPHELES WALKERI* THEOBALD IN THE TENNESSEE VALLEY

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The mosquito, *Anopheles walkeri,* is more widely distributed, occurs in greater numbers, and bites man more readily in the Tennessee Valley than is generally known. It breeds in relatively permanent aquatic habitats containing emergent plants such as cattail, sawgrass, or lizard-tail. Although the larval habitat of *A. walkeri* and *Anopheles quadrimaculatus* may be essentially the same, the diurnal resting places of the adult mosquitoes vary so greatly that they are rarely taken together.

In past years, the importance of *A. walkeri* as a pest or as a possible vector of malaria in the Tennessee Valley may have been overlooked because the adults, which resemble *A. quadrimaculatus* superficially, have never been identified from specimens taken in barn collecting stations during TVA's routine inspection seasons from May through September. During the past 21 years, 166,518 mosquito station inspections have been made throughout the Valley and while over a million *A. quadrimaculatus* and numerous other anophelines have been recorded, no *A. walkeri* has ever been detected in these routine inspections.

During the summer months adults of *A. walkeri* show a strong preference for diurnal resting sites on emergent aquatic vegetation rather than in barns, nail kegs, or privy-type structures where other native anophelines are frequently found. In 1947, from approximately 40,000 anopheline adult mosquitoes collected in nail kegs around Blackwell Swamp, only one *A. walkeri* was detected, although they constituted about 30 percent of the anophelines taken in night collections (2, 3). In 1949 mosquitoes were collected from a series of privy-type resting shelters and nail kegs along the margin of Blackwell Swamp. From the total mosquitoes collected and identified, only one female *A. walkeri* was captured while 60,253 *A. quadrimaculatus,* 448 *A. crucians,* 289 *A. punctipennis,* and small numbers of fifteen culicine species were taken (5).

Although it appears that *A. walkeri* avoids resting in barns and other diurnal shelters frequented by *A. quadrimaculatus* during the hot, summer months, small numbers were found in barns during the cooler, fall months after routine inspections were terminated. An inspection of a barn about ⅝ mile north of Blackwell Swamp during August and September of 1948 yielded only *A. quadrimaculatus;* however, during a nocturnal visit on October 29, females of *A. walkeri* were observed biting in the barnyard, and several engorged specimens were found the next day randomly distributed within the barn. Subsequent inspections of this barn showed that engorged females continued to frequent this barn until November 23 when a final series of five engorged specimens were collected. Later collections were negative for *A. walkeri* although *A. quadrimaculatus* and *A. punctipennis* were found in about equal numbers.

By means of night-biting collections, *A. walkeri* in the Tennessee Valley was first detected in 1939 at Live Oak near Paris, Tennessee. The following year it was found at two other separate, but similar, ponded situations where the natural drainage of small streams had been blocked for several years by silt from the natural erosion.

In 1947, several night collections in the

Wheeler Reservoir area revealed *A. walkeri* to be present and abundant. The most favorable type of habitat in this area appeared to be where lizardtail, *Saururus cernuus* L., and waterwillow, *Decodon verticillatus* (L.) Ell., were the dominant emergent plants (3). One of the best collecting sites was at Blackwell Swamp, an old spring-fed tupelo gum swamp now largely cleared of trees. Extensive bands of lizardtail were present along the open margin and smaller stands had colonized the periphery of the old emergent tupelo stumps (Fig. 1). The adults of *A. walkeri* were commonly found resting during the day a few inches above the water level on the stems of lizardtail, waterwillow, and in the old tupelo stumps. Because of their leafy canopy and naked stems, these plants actually afford the resting mosquitoes more protection from the elements than the cattail type of vegetation with which they are usually associated.

Night collections appear to give the most reliable index to the density and distribution of *A. walkeri*. A technique for making night collections was first used in 1939, and, since that time, TVA entomologists have found it to be a very satisfactory method for detecting the presence of *A. walkeri* as well as other night-biting mosquitoes. This collecting method, which has been called the "parked car technique," may be used as follows:

"Drive an automobile to the collecting site just before or at sundown and park facing the breeding area; leave headlights on for the first five minutes after dark, then turn them off; open all doors and windows, and turn on overhead domelight. If only one collector, sit in back seat and expose the arms and legs as

Fig. 1. Old tupelo stumps and associated stands of frost-damaged lizardtail as viewed from the west margin of Blackwell Swamp near Triana, Alabama, October 19, 1948.

feeding surfaces. With flashlight, aspirator, and killing tube (or cages), collect the mosquitoes as they appear" (2, 3).

In actual practice, many more specimens are captured from the interior surfaces of the car (*i.e.,* windshield, rear window, doors, and upholstery) than from the human bait. The open doors and interior of the car furnish the mosquitoes suitable temporary stopping places before and/or after they feed, and most of them are usually captured before they succeed in taking blood. This technique takes into consideration several characteristic reactions of *A. walkeri* including a marked attraction to light, a suitable host, and a period of flight at dusk.

From the records on 6,140 specimens thus obtained, from September 1948 to August 1949 it appears that *A. walkeri* was active well into the fall and tolerates a considerably wider temperature range than *A. quadrimaculatus* (6). On October 17–18, frost killed the emergent lotus and most of the tall lizardtail, the normal diurnal resting sites for *A. walkeri.* The reasons for an unusual surge of activity noted in collections in late October of 1948, and the occurrence of the species in barns in October and November are not clearly understood, but such activity could be related to the winter kill of vegetation normally used for diurnal resting sites, thus forcing the mosquitoes to seek other types of shelter along the wooded shoreline, and closer to the collection site. Further, the cooler temperatures may have influenced the adult mosquitoes to rest longer in the car, where they were caught more readily. It is also quite possible that a buildup of emerging adults occurred during the cold period previous to the October peak and conditions were not favorable for adult flight activity until the end of October.

As a part of TVA's malaria control program, Blackwell Swamp was dewatered after July 1949 and anopheline production in this area was virtually eliminated. Although collections were continued here throughout the remainder of 1949, these negative data are not presented because, after this drastic ecological change in the mosquito breeding grounds, the results are not comparable to data previously collected to show the seasonal occurrence of this species.

Females of *A. walkeri* showed a secondary feeding peak at dawn along the swamp margin, but it was not nearly so marked as in the early evening. Feeding in bright sunlight was also observed for this species. On October 19, 1948, at least four females entered the parked car on the west side of the swamp and attempted to feed on man during the 1100–1200 hour period.

Adults were captured on several occasions in the open and in barns approximately 5/8 mile from Blackwell Swamp without the factor of attraction to light. One collection two miles distant was negative. At Reelfoot Lake, Tennessee, specimens of *A. walkeri* were recovered in traps at a town about 2 miles from the nearest breeding area, but these mosquitoes may have been influenced by light along the way. Release and recovery of marked specimens for a more accurate determination of the flight pattern were attempted; however, only small numbers of marked individuals were released and none were recovered (1).

Along the swamp margin at Reelfoot Lake *A. walkeri* made short interrupted flights. In the late afternoon hours it has been seen pausing on the upper leafy surfaces of buttonball as it moved from one group of plants to another (6). Such series of short flights appeared to be a normal pattern of dispersal, but, of course, this type of visual observation could not be made for long flights. Other workers observed that *A. walkeri* does not often fly out to the center of a lake "because there is no food to be had there" (1). They operated a light trap from a boat located on open water about 100 yards from the marshes and caught only 3 *A. walkeri,* while simultaneous collections at an equal distance ashore yielded 141 *A. walkeri.*

On October 28, 1948, approximately 1,400 female *A. walkeri* were captured on the west bank of Blackwell Swamp and they were released from the opposite east

bank the same evening (2,000 hrs.) after they had been thoroughly dusted with rhodamine B.* A flashlight was set up across the swamp on the original capture site with the thought that it might possibly attract the dyed adults back across approximately 1,000 feet of water surface which was broken by stumps, lizardtail, and lotus. A parked car collection the early part of the next evening (Oct. 29) showing the number of dyed specimens recaptured per 15-minute collecting period is presented in table 1.

TABLE 1.—Parked car collections of female *A. walkeri* on west bank of Blackwell Swamp, Wheeler Reservoir, October 29, 1948

Time (CST)	*A. walkeri*	+ Rhodamine B
1630–1700	511	33
1700–1730	636	36
1730–1800	416	34
1800–1830	218	11
1830–1900	79	4
1900–1930	38	0
Total	1,898	118

A subsequent collection of 304 *A. walkeri* at this same collection point on November 3 yielded two more dyed specimens making a total of 120 or 8 percent of the marked individuals released. Therefore, at Blackwell Swamp, this species returned to its original location across water, but whether it came in short or long flights is unknown (6). In one night collection (August 26, 1947), 29 female *A. walkeri* were taken during a three-hour period at Cane Landing which was approximately 1,100 feet across the open water of the Tennessee River from Blackwell Swamp, the nearest known breeding grounds of *A. walkeri* (4).

Limited observations at Reelfoot Lake indicated that during the spring and fall *A. walkeri* was captured more frequently on man than in a nearby light trap run concurrently with the biting collections (7). It was also observed that *A. walkeri* was active primarily at ground levels when paired biting collections on man were made at ground, 30-ft., and 75-ft. elevations on the margin of the cypress forest (8). These biting collections were made without the use of lights. Where light traps have been operated simultaneously at the base and atop a 100-foot bluff, catches of *A. walkeri* have been considerably more plentiful at the base of the bluff (1).

In recent years, TVA's malaria control operations, especially shoreline topography changes, dewatering, and water level management, have eliminated many situations which at one time appeared to be optimum breeding places for *A. walkeri*. Only occasional specimens are now recovered, and these are found in relatively permanent pooled areas not materially affected by the seasonal recession phase of the reservoir operation or in swampy areas apart from the main reservoir but within the Tennessee River watershed.

The following is a record of the occurrence of *A. walkeri* in the Tennessee River watershed. The site, or condition under which collected, is indicated by the following abbreviations: B=barn; C=parked car; BM=biting man in open; L=larva; P=pupa; RP=resting on plant stem; and RK=resting in nail keg.

Tennessee. Paris, VII–17–39 (BM–8), V–17–40 (BM–15), VI–5–40 (C–4), VI–52 (BM–6); Bruceton, V–31–40 (C–1); Camden, VI–13–51 (C–1).

Alabama. Triana, VII–16–47 (C–1), VII–17–47 (C–13), VIII–47 (RK–1), IX–28–48 (C–88), IX–29–48 (C–85), X–1–48 (C–9), X–4–48 (L–5), X–10–48 (L–3), X–12–48 (P–1), X–13–48 (C–231) (RP–4), X–19–48 (C–4) (BM–1), X–20–48 (C–10) (L–2), X–21–48 (C–181), X–27–48 (C–673) (L–2), X–28–48 (C–1456) (B–3), X–29–48 (C–1903), XI–3–48 (C–304), XI–7–48 (B–1), XI–9–48 (C–15) (B–1), XI–10–48 (B–1), XI–17–48 (B–3) (C–14), XI–18–48 (B–2), XI–23–48 (B–5), XI–29–48 (RP–1), XII–13–48 (C–12), XII–14–48 (C–22), V–16–49 (C–1), VI–

* National Aniline Division, Allied Chemical and Dye Corp., New York, N. Y.

14–49 (C–3), VI–22–49 (C–57) (RK–1), VI–27–49 (C–42), VII–5–49 (C–94), VII–18–49 (C–6), VII–25–49 (C–829), VII–27–49 (C–4), VIII–15–49 (C–2), VIII–23–49 (C–3), VIII–30–49 (C–1), IX–19–49 (C–1); Decatur, VII–21–47 (C–4); Redstone Arsenal, VII–24–47 (C–5); Mooresville, VII–24–47 (C–1); Somerville, VIII–5–47 (C–57), VIII–26–47 (C–18) (BM–11); Smithsonia, X–15–48 (C–1), X–20–49 (C–7), X–24–49 (C–1); Greenbrier, VIII–26–49 (C–3), VIII–29–49 (C–1), IX–14–49 (C–2), X–17–49 (C–1), XI–30–49 (C–1), VIII–4–55 (BM–1).

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STUDIES ON THE VIABILITY OF SALT-MARSH MOSQUITO EGGS [1]

W. L. BIDLINGMAYER AND H. F. SCHOOF

During 1953–54 studies were conducted in the Savannah, Georgia, area to study the viability of overwintering eggs of the salt-marsh mosquitoes, *Aedes taeniorhynchus* (Wied) and *Aedes sollicitans* (Walk).

In the first test series, soil samples of 0.5 square foot each were taken at monthly intervals from five breeding areas (A—E; see table 1) to observe the influence of natural conditions on egg viability. The samples were obtained at random except in Area E, where they were taken in a regular series running from low to high elevations. None of the breeding areas studied had received a thorough flooding since the spring tides of October and November, the winter rains having caused only local and partial inundation.

All samples were held in the laboratory at 80° F. for 1 week to break the dormant condition of the eggs. Previous observations had indicated that eggs flooded immediately after the samples were removed in the field during the winter period produced relatively few larvae. However, adequate hatching could be obtained by conditioning the eggs for 1 week at 80° F. The conditioned samples were flooded with tap water, and the number of larvae counted 24 hours later.

In the second test series, approximately

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TABLE 1.—Proportions of *A. taeniorhynchus* and *A. sollicitans* dipped from breeding areas from October 1953 to April 1954 near Savannah, Ga.

Date	Area	No. of Larvae Identified	Percent *A. taen.*	Percent *A. soll.*	Percent Other
11/27	E	23	0	100	0
12/24	A	98	1	82	17
1/21	A	148	0	76	24
3/3	A	103	16	81	3
4/6	C	67	78	22	0
4/13	E	71	87	13	0

75 square feet of soil samples were collected in late January, 1954, from a salt-marsh area known to contain mosquito eggs. The eggs in this area probably were laid during September and October, 1953, and had not been flooded prior to their collection. The samples were stored in trays in an unheated shed where they were kept in a moistened condition by periodic subirrigation. At weekly intervals, samples aggregating several square feet of sod were processed for flooding as in the first test series. After May 1 the rise in ambient temperatures permitted the samples to be flooded without preconditioning them.

In the third series of tests beginning in January, 1954, 30 soil samples of approximately 0.5 square foot each were collected at monthly intervals from selected sites in Area E. Each sample was then divided in half. One half was stored in an unheated shed and became extremely dry, while the other half was conditioned for one week and then flooded. At monthly intervals following the original collection date, five of the stored samples would be removed, conditioned for 1 week, and flooded. The mean number of larvae produced was then compared with the average number of larvae produced by the duplicate halves of the samples at the time of collection.

Prior to January 1, identification of the mosquitoes was made by rearing a portion of the newly hatched larvae to the fourth instar or to the adult stage. During January and February, the first instar larvae were also identified, and these determinations were found to give essentially the same proportions of species as was obtained by the rearing procedures. Consequently, all subsequent identifications were limited to first instar larvae.

Results from test series I indicated that on the basis of similar rates of larval densities per square foot for the winter and spring periods, eggs deposited the preceding fall or earlier apparently survived the winter with only slight losses in viability. Eggs from Area D showed the greatest drop in the number of larvae produced, the December and January samples averaging 270 and 310 larvae, respectively, as compared to the 96 and 83 larvae recorded for February and April. In the remaining areas the larval densities in March and April, except where spring tides flooded the marsh in early April, approximated those for November and December. In Area E larval densities for February and March were 3 to 10 times those present in the early winter. The recovery of eggs from the same area does not preclude such variation in numbers since the female mosquitoes frequently oviposit more heavily in one site or zone than in another.

With the exception of Area D, *A. taeniorhynchus* was predominant over *A. sollicitans* in the majority of the soil samples. Other species of mosquitoes also were produced from the various samples in the following order by numerical rank: (Area A) *Aedes vexans, Psorophora confinnis,* and *Culiseta inornata;* (Area B) *Aedes vexans, Aedes infirmatus, Psorophora* spp.; (Area C) *Aedes vexans* (1 specimen); and (Area D) *Aedes* sp., *Psorophora* sp., and *Aedes vexans.*

Table 1 shows the numbers of larvae

collected from breeding Areas A, C, and E as a result of natural flooding. It may be seen that midwinter hatches are composed almost entirely of *Aedes sollicitans*. However, observations indicated that all of the eggs of *A. sollicitans* present in an area do not hatch when flooded. For example, sod samples taken from beneath water containing large numbers of *A. sollicitans* larvae in January were shown to produce additional *A. sollicitans* larvae when the samples were held in the laboratory for 1 week and then flooded. The same samples also yielded *A. taeniorhynchus* larvae, the relative proportion of the two species being 67 percent (*A. taeniorhynchus*) and 33 percent (*A. sollicitans*). Sod samples removed from an unflooded portion of the same breeding area produced larvae of these two species in approximately the same proportions. Presumably, *A. sollicitans*, being better adapted to cooler climates, is able to develop small broods during the warm portions of the winter season.

TABLE 2.—Number of larvae found per square foot on soil samples collected in January, 1954, and flooded at various intervals between February 3 and June 29, 1954, Savannah, Georgia

Date Flooded	Square Feet Sample Flooded	Larvae per Sq. Ft.	Percent	
			Aedes taeniorhynchus	*Aedes sollicitans*
2/3	5	1,293	84	16
2/10	5	1,742	81	19
2/17	4.5	1,044	79	21
2/25	4.5	1,294	—	—
3/3	4.5	874	78	12
3/10	4.5	951	—	—
3/17	4.5	1,707	79	21
4/2	4.5	1,445	—	—
4/8	4.5	1,051	91	9
4/15	4.5	336	69	31
4/22	4.5	640	—	—
4/29	4.5	1,012	—	—
5/6	4.5	427	—	—
5/13	4.5	1,030	—	—
5/20	4.5	475	65	35
5/27	4.5	1,009	—	—
6/4	3	1,982	81	19
6/18	3	339	—	—
6/24	2	71	—	—
6/29	4.5	2	—	—
		Ave.	80	20

In addition to the above two species of salt-marsh mosquitoes, specimens of *Culiseta inornata, Culex salinarius, Aedes vexans,* and *Anopheles bradleyi* were found in Area A.

In the test series 2 (table 2), and 3, the eggs of both species survived the winter with little loss in viability. Not until June and early July did a marked decrease in viability occur. Where duplicate half samples of sod were flooded at monthly intervals after the date of collection, the numbers of larvae were similar until the July

flooding. The duplicate half of samples which produced 584 and 708 larvae when flooded initially in January and February yielded 625 and 404 larvae, respectively, when flooded in June. In comparison, samples collected in January and February and flooded in July produced 32 and 4 larvae, respectively, even though the duplicate half samples yielded 332 and 884 larvae when flooded in January and February. None of the samples held until August produced larvae despite collection of sod as late as April.

Summary. Laboratory evaluation of winter-collected soil samples from salt marshes near Savannah, Georgia, indicated that eggs of *Aedes taeniorhynchus* and *Aedes sollicitans* show little loss in viability over the period December 1 through June 1. Subsequent to early June, the percentage of viable eggs decreased markedly.

THE IMPORTANCE OF MOSQUITO BREEDING IN TREE HOLES WITH SPECIAL REFERENCE TO THE PROBLEM IN TAHITI

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AND
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Although it is a well-known fact that the tree hole serves as a common site for the breeding of certain mosquitoes, this location is frequently dismissed as a source of minor importance. This may be the result of beliefs that (1) the species involved are exotic forms of interest only to the taxonomist, (2) the species are unimportant as vectors of disease or as pests of man, (3) tree holes are uncommon, and (4) production of mosquitoes from tree holes is small compared with other types of breeding locations.

It is the purpose of this account to show that tree holes, under certain conditions, constitute a breeding place of major importance. These observations are based primarily upon recent work carried out in Tahiti during the course of studies on the ecology of *Aedes polynesiensis* Marks in connection with the joint Filariasis Control Program of the Institut de Recherches Medicales de l'Oceanie Francaise and the University of California, Los Angeles.[3]

The authors express their appreciation to Dr. Jacques Kerrest, Director, Institut de Recherches Medicales, and to Professor John F. Kessel, Department of Infectious Diseases, School of Medicine, University of California, Los Angeles, California.

Importance of Tree Holes as Sources of Mosquitoes. In the recent compilation of information on approximately 1,800 species of mosquitoes, Horsfall (1955) has listed the common breeding sites for about 1,300. Of these, almost 350, or one-quarter, are reported to be found breeding in tree holes, rot holes or bamboo stumps. The species are distributed among 17 genera and include at least 12 species of *Anopheles* and approximately 190 species of *Aedes*.

Nasir (1952) made the observation that "the output of mosquitoes from small, obscure and negligible water collections like tree holes and bamboo stumps may be

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very considerable under tropical conditions." Shute (1954) has stated that indigenous malaria in England is apparently transmitted by the tree hole breeding *Anopheles plumbeus* Stephens. Portmann (1951) reported that in the Sacramento Valley Area, California, the tree hole breeding *Aedes varipalpus* "was a severe pest in areas heavily treed with stands of old trees." Gray (1951) has mentioned briefly that the "larvae of this species have been found in over 15 species of trees in California." In Tahiti, of the 9 species of mosquitoes known to be present, three, *Aedes polynesiensis* Marks, *Aedes aegypti* (Linn.) and *Culex atriceps* Edwards, are regularly found breeding in tree holes. A fourth species, *Culex quinquefasciatus* Say, is found occasionally in association with these other species.

Aedes polynesiensis, the vector of nonperiodic filariasis in the South Pacific, is the most common tree hole breeding mosquito in Tahiti. The larvae of this species are found also in rat-eaten coconuts, bottles, tin cans, drums, crab holes, etc. Of the various types of breeding containers, the tree hole is important for this species in Tahiti because of its permanence, abundance and proximity to human habitation.

Larvae of this species have been found commonly in rot holes or tree holes in the following common trees of Tahiti: Breadfruit, *Artocarpus incisa;* Mape, *Inocarpus edulis;* Coconut, *Cocos nucifera;* Mango, *Mangifera indica;* Avocado, *Persea gratissima;* Guava, *Psidium guajava;* Burau, *Hibiscus tiliaceus;* and Flame Tree, *Poinciana sp.* Almost all of these trees are of economic importance in Tahiti and are usually planted close to dwellings. Since *Aedes polynesiensis* has a short flight range (Jachowski, 1954), this becomes a matter of importance in the transmission of filariasis in Tahiti.

In an effort to determine quantitatively the importance of the different types of trees, a total count of the various trees in an area 100 meters by 2,000 meters was made, i.e., fifty meters on each side of the circumferential road for a distance of two kilometers. A total of 2,416 trees was enumerated and a total of 84 tree holes with larvae of *Aedes polynesiensis* was found. The ranking order for each species of tree was as follows:

TABLE 1

	No.	No. Breeding	Percent Breeding
Flame Tree	11	5	45.4
Breadfruit	291	56	19.2
Mango	115	8	6.9
Miscellaneous *	149	10	5.3
Burau	193	3	1.6
Coconut	1,657	2	0.1

* Includes Bamboo, Ironwood, Kaya, Kapok, Acacia, Guava and others not furnishing breeding places frequently enough in this survey to count separately.

These figures apply only to the particular area where the census was made, as the distribution of trees varies from area to area and it would be necessary to determine the importance of each species of tree for each area. A careful examination was made of the breadfruit trees in an area of 1 hectare around two native style houses. The following results were obtained:

TABLE 2.—Area—10,000 square meters or approximately 2 acres

Number of breadfruit trees—27
Number of trees with one or more tree holes—13, or 50 percent
Number of tree holes—47, or an average of 1.7 per tree
Number of tree holes with water—43, or 91.5 percent
Number with larvae of *Aedes polynesiensis*—14, or 29.6 percent

This can be compared to a survey of rat-eaten coconuts made in an area of equal size. (See Table 3)

The breadfruit tree stands out as a major source of mosquito breeding in Tahiti because of the native agricultural practice of "topping" the trees. This is done

TABLE 3.—Area—10,000 square meters or approximately 2 acres. Area not cleaned up but coconuts partially removed

No. of trees—95
No. of rat-eaten coconuts on ground—542
No. of rat-eaten coconuts with water—147, or 27.1 percent
No. of rat-eaten coconuts with larvae of *Aedes polynesiensis*—8, or 1.4 percent

for the purpose of stimulating the growth of side branches and causing the fruit to develop within reach. The breadfruit when undisturbed grows to great heights with a large single trunk. It is extremely rare to find a breadfruit tree which is not a pollard. This operation initiates an area of center rot and a large cavity usually results. The cavity may be found as high as 90 to 100 feet above the ground and containing immense numbers of larvae.

The tree most frequently found in Tahiti is the commercially important coconut tree. It is widespread in the shore regions and surrounding all areas of habitation. Water-holding cavities may develop in the trunk as the result of cutting climbing steps. Fortunately this is infrequently done in Tahiti. Rat-eaten coconuts are a more important source of mosquitoes than the coconut trees. They are being reduced gradually through a tree-banding program promoted by the French Government in Tahiti.

The problem of the breeding of *Aedes polynesiensis* in tree holes is complicated by the resistance of the eggs to drying (Ingram 1954). First stage larvae have been taken from tree holes within 30 minutes of the introduction of water into dry holes. On several occasions, 4th stage larvae and pupae have been recovered from the moist but not wet debris removed from the bottom of a tree hole after a period of dry weather.

Methods of Control. Various methods for the elimination and control of mosquito breeding in tree holes are undergoing trial in Tahiti. Although sufficient time has not yet elapsed to permit a complete appraisal, it is believed that a summary of the methods on trial may be of value to mosquito control workers in other areas with similar problems. The methods can be conveniently considered under (1) chemical treatment, (2) filling and (3) natural control.

Chemical Treatment. Herms and Gray (1944) recommended the use of undiluted cresylic acid as a larvicide for tree holes that could not be filled with cement. They also suggested that DDT would probably be more effective because of its strong residual effect. DDT, lindane and dieldrin have all proven effective in Tahiti in tree holes for periods up to three months. The insecticides were applied in concentrated form by means of a hand-oiler and no attempt was made to measure the dosage accurately. The inspector placed one or two squirts from the machine into the hole irrespective of the size. Variations in effectiveness appear to depend upon the amount of debris in the holes, the amount of rainfall and the quantity of insecticide introduced. In general, chemical control for mosquito breeding in tree holes is considered to be of limited value because of impermanence and necessity of repeated applications.

Filling. The use of tree surgery and subsequent filling with a cement mortar has much to recommend it, as a permanent means of eliminating mosquito breeding tree holes. The usual procedure is to cut out all rotten wood and fill the cavity with a mortar composed of one part Portland cement mixed with 3 parts of sand, with enough water to give a semi-solid mixture. If large holes are to be filled, wire reinforcing will be necessary. If properly done, the growth of the cambium layers of the tree eventually closes over the hole. The coconut tree does not have a cambium layer and hence this overgrowth does not occur. Secondary rotting around the edges of the cement will occur unless precautions are taken to allow complete drainage of water. Thus, holes in coconut trees are not readily eliminated by cementing. This method is excellent for urban areas where the numbers of trees

are small, but is of limited use in extensive rural sylvan areas owing to the cost of materials and semi-skilled labor. Recently trials have been initiated using asphalt asbestos cements (Texacote 370 and Texaco Plastic Car Cement) to top off a filling of sand and gravel. These plastic materials have the advantage of adhering firmly to the edge of the cavity, being flexible and not requiring extensive tree surgery. As yet, it is not possible to make any statement on the permanence or cost of control by this method.

NATURAL CONTROL. The introduction of predatory mosquitoes living in tree holes belonging to the genus *Toxorhynchites* was first suggested by Buxton and Hopkins (1927) and Muspratt (1951). Paine (1943) reports that 10 years after the introduction of *Toxorhynchites splendens,* it has been recovered from eight different islands of Fiji. The African species, *Toxorhynchites brevipalpis,* was introduced into Hawaii in 1951 (Bonnet & Hu 1951) and subsequently a colony was established in Tahiti. Although over 3500 larvae and adults have been released in Tahiti since 1954 in a single location, no wild bred specimens have been recovered.

Although this method of control is without cost and continuous when the introduction is successful, it is doubtful that the resulting control is very effective, owing to the fact that predator species do not reproduce as fast as the mosquitoes they are intended to control.

A new type of natural control which has proved successful in the rural areas of Tahiti is almost filling the tree hole with dirt and gravel and placing a living plant, usually a fern, at the top. The roots of the plant penetrate the soil and rocks and act as a "sponge" to withdraw water from the tree hole cavity. This water is then given off by the plant by transpiration. Various species of ferns have been utilized, particularly *Asplenium* sp. If the tree hole is in a pasture and near the ground, a fern must be chosen which is unattractive to cattle. This can be easily determined by observing the plants present in the pasture, and not eaten by the cattle. Usually one can be found which will serve the purpose. As the fern grows, it completely adjusts to the cavity of the tree even though the tree hole may increase in size. The fern roots firmly attach the plant so that it is not dislodged by heavy rains or wind. A series of tree holes with mosquito larvae were treated in this manner in Tahiti, and after nine months the ferns had grown actively. Also the tree holes contained no water or larvae. This method has the obvious advantages that the materials are always at hand, can be applied by unskilled workers. It is esthetically attractive and inexpensive, as well.

SUMMARY. A review of the problem of mosquito breeding in tree holes is presented with particular reference to the control of *Aedes polynesiensis,* the vector of filariasis in Tahiti. A survey showed that the most important species of tree was the breadfruit (*Artocarpus incisa*) because of its abundance, proximity to dwellings, and the agricultural practice of "topping" or pollarding, resulting in rot holes. A survey showed that there was an average of 1.7 rot holes per tree and that of these 29.6 percent contained larvae of *Aedes polynesiensis.* Methods for the elimination or control of mosquito breeding are discussed including chemical, filling and natural methods. A new method is presented which is cheap, simple and relatively permanent. A fern or similar plant is placed in the rot hole after partial filling with dirt or gravel. The growth of the fern roots the plant firmly in place, and water is withdrawn from the hole by transpiration. Preliminary trials of 9 months duration have shown this method to be effective in eliminating mosquito breeding.

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OPERATIONAL AND SCIENTIFIC NOTES

LABORATORY COLONIZATION OF *Culex stigmatosoma.** The successful establishment of laboratory colonies of *Culex tarsalis* (Brennan & Harwood, 1953; Brennan, Rush & Hubert, 1954; Hubert, Rush & Brennan, 1954) has suggested the possibility that other species of mosquitoes, previously refractory to laboratory cultivation, might be colonized using the same type of technique.

There is apparently no report in the literature of the successful colonization inside a laboratory of *Culex stigmatosoma*. Brookman & Reeves, (1952) according to Trembley (1955), were able to raise *C. stigmatosoma* in outdoor cages, during spring and summer. Brookman, according to a personal communication from R. E. Bellamy (1955), carried a self-perpetuating colony of *C. stigmatosoma* for several months in the summer of 1951 on a screened vestibule adjacent to the laboratory at Bakersfield, but no details have been published. Inasmuch as we have been successful in maintaining *C. tarsalis* in the laboratory for nearly two years under controlled illumination, we decided to apply the same techniques to a colony of *C. stigmatosoma*.

Through the courtesy of Mr. John Shanafelt of the Orange County (California) Mosquito Abatement District, we obtained a number of egg rafts of *C. stigmatosoma* on September 24, 1954. These rafts hatched in the laboratory and the adults produced were placed, on October 10, 1954, in a cage 17½" x 17½" x 36" high and exposed to a lengthened period of daylight of approximately 16 hours, with one hour of twilight, 6½ hours darkness and one-half hour of increasing illumination. After two days of conditioning, 20 female *C. stigmatosoma* along with 10 males were exposed with a canary overnight, but only 2 females engorged. The mosquitoes were again exposed to a canary on the nights of October 13, 16, and 17, but only 2 or 3 more mosquitoes bit, and no egg rafts were obtained.

On November 3, 1954, about 60 *C. stigmatosoma* of both sexes, which had hatched from the rafts collected on September 24, were exposed to 24-hour light conditioning in the same cage as the one used previously. The next night, 20 females bit when exposed with a canary; 2 rafts were found on November 10, 4 on November 12, and 8 on November 14. In all cases, these hatched 2 days after they were laid, and by December 1 had produced a sufficient number of adults for breeding a second generation in captivity.

On this date, about 50 adult mosquitoes were transferred to a smaller cage 12" x 12" x 36" high and were maintained without controlled illumination in a window-lit laboratory. The adults exposed with a canary on December 1 again produced fertile eggs, with adults emerging on December 19.

As of the present date (April 12, 1955) 3 more generations of *C. stigmatosoma* have been obtained in the laboratory in the smaller of the two cages listed above and without controlled illumination. Laboratory temperature does not drop below 72° C., and a new generation of adults hatches out about 21 days (18–26 days) after the females of the previous generation have taken a blood meal. Fertility is high and there seems to be no reason why the strain should not continue breeding in captivity.

The adaptation of *C. stigmatosoma* to laboratory conditions with successful mating in small cages without controlled illumination is analogous to a similar type of adjustment exhibited in the Rocky Mountain Laboratory colony of *C. tarsalis* (Brennan, Rush & Hubert, 1954; Hubert, Rush & Brennan, 1954). Our own colony of *C. tarsalis*, obtained originally from the Rocky Mountain Laboratory through the courtesy of Dr. Brennan, is being maintained very satisfactorily under these conditions.—Gordon H. Ball & Jowett Chao, Department of Zoology, University of California, Los Angeles.

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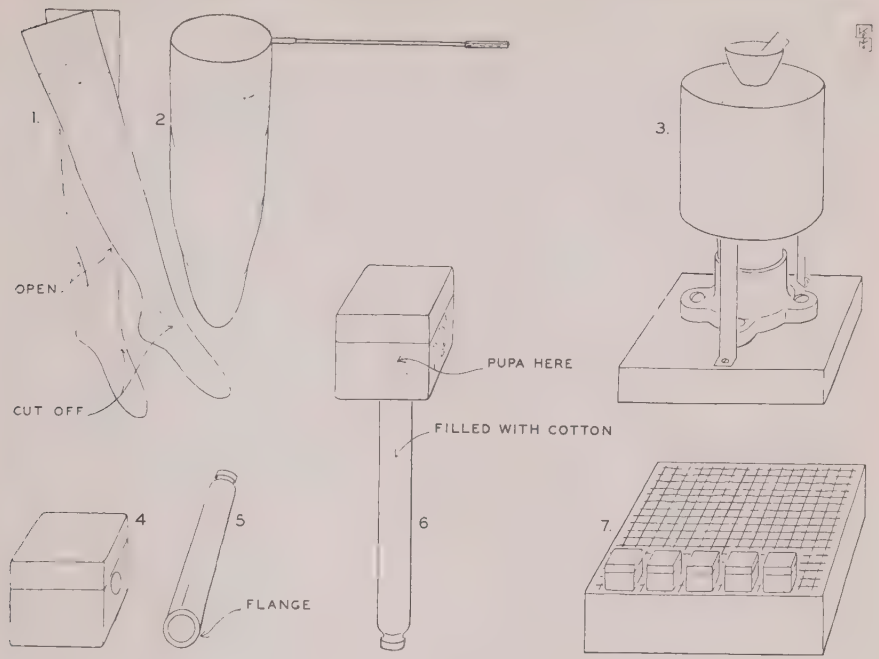
DO-IT-YOURSELF ENTOMOLOGICAL EQUIPMENT: Net for capturing *Culicoides*, midges, black flies and mosquitoes in flight: Carefully open the back seams of two or three nylon stockings from the heel to the top; then cut the feet off at the desired arc, Fig. 1. Two stockings give a net

* Supported in part by a grant No. 1857 from the United States Public Health Service, and from the Board of Research of the University of California.



diameter of approximately 9 inches, Fig. 2, and three stockings approximately 13½ inches. Outsize stockings offer a still larger net diameter. Carefully sew the sections together with nylon thread, using overcast stitching for the rolled seams. The material will not "run" at the seams because it is not taut. The tops of the stockings already provide a deep hem for the insertion of the frame loop. Specimens can be quickly removed from the inverted net with an aspirator while the collector is looking *through* the net. If the net becomes wet while capturing surface-skimming insects a few swings will suffice to dry it. A plastic cover, similar to those used for tennis rackets, will prevent the net from becoming snagged when not in use and the cover also serves as a handy seat when the ground is damp.

Heater for Clearing Insects in KOH or Lactic Acid Solutions, Fig. 3: The necessary materials for this heater are: a block of wood about 3 x 3 x ¾ inches thick; three strips of aluminum about ¼ inch wide and ¾ of an inch longer than the combined length of an electric light socket plus a 40 or 60 watt bulb screwed in place; a tin can slightly bigger than the diameter of the light bulb; an electric cord and switch; a small crucible about an inch in diameter, containing water and a little shell vial containing the solution and specimen for clearing. Trace the outline of the can on the block of wood and mount the bulb socket in the center of that circle. Bore a little hole in the center of each strip of aluminum about ¼ inch from one end. Bend each strip at a right angle about ½ inch from the end containing the hole. Screw the metal "L's" to the block just inside the circle and equidistant from each other. Insert the switch in the cord. Screw the bulb in place and invert the tin can over the aluminum supports. Place the vial containing the solution and the specimen in the crucible of water and heat them on the can. My heater has been in use periodically ten years with only one change of bulb.

Individual Pupal-Adult Emergence Cages for Blackflies: The following rearing equipment has proved very satisfactory for association of pupal and adult blackflies, yielding almost 100 percent perfect adult specimens and requiring no daily care other than a glance to see which ones have emerged.

The necessary materials for the cages consist of transparent plastic boxes 22 x 22 x 20 mm. high; glass tubing 63 x 8 mm. (dental "procaine" tubes with the lip were used); nylon "tape" or ribbon; absorbent cotton; and household cement. The racks are made of ½ inch hardware cloth stapled to a square wooden frame about 10 x 10 x 2¼ inches high, which fits over pans 8 x 8 x 2 inches high containing about an inch of water.

Drill a hole through the bottom of the plastic boxes just big enough to accommodate the large

end of the dental tubes, Figs. 4 and 5. Drill a smaller hole through each of two sides of the cages and glue patches of nylon mesh ribbon over these vents. In the absence of equipment for heating glass to put a flange on the broad end of the tubes, a ring of household cement will serve the purpose. The tubes may be cemented to the cages intruding a few mm. or they may be just dropped through the hole, resting on their flange, Fig. 6. The latter takes less storage space when the equipment is not in use, but requires more careful handling, to avoid jamming the tube against the lid and squashing the pupa when moving the cages about on the racks. (Some cages were fitted with thin sheet-cork bottoms, containing a hole for the tube, and a strip of adhesive tape on the two sides not containing the vents, while others were roughed-up on the inside with steel wool. These provisions for providing the flies with better footing are apparently not necessary.)

Pack the tubes firmly, but not too tightly, with absorbent cotton, being careful to fill the last quarter inch with a separate wad of cotton. Drop the tubes into the cages and place the cages on the racks with the tubes extending through the hardware cloth so that the bottoms of the tubes are immersed in water, Fig. 7. After the cotton becomes wet at the top the loose strands can be tamped into place. Then put an intact dark pupa, ventral side down, on the moist cotton and replace the lid of the box. When the adult emerges the date can be written on the lid with a wax pencil and the following day the specimen killed and labeled along with the associated pupal exuviae. Specimens are easily killed by inverting the cage and carefully removing the lid, then tapping the cage while it is held about ¼ inch above a Syracuse dish of alcohol. The writing can be wiped off the lids and the cages used again. After a few weeks the top of the cotton sometimes becomes corroded or mouldy so the uppermost wad should be removed and a clean one substituted.—Kathryn M. Sommerman, Arctic Health Research Center, Public Health Service, Department of Health, Education, and Welfare, Anchorage, Alaska.

THE EGG AND IDENTITY OF ALASKAN *Anopheles*. About a hundred anopheline eggs were skimmed from a pond at Eklutna, Alaska on June 6, 1956 and examined on the spot under the binocular microscope. Twenty of 25 selected perfect, unhatched ova were plainly banded dorsally, fitting reasonably well the description given by Rozeboom (1952, Am. J. Trop. Med. & Hyg. 1:477–83) of barred eggs of *Anopheles earlei* Vargas in Montana. Departures from Dr. Rozeboom's photograph and description included: (1) one egg grey, unicolor; (2) four eggs mottled, unbanded; (3) nearly half the eggs with two pigmented lines on the dorsum along the floats, which is evident also in Marshall's fig. 84, egg photograph 3 of *A. maculipennis* var. *typicus* of Europe. A large majority of the seventy-odd remaining imperfect ova, mostly hatched, also showed transverse bars under the lowest power of the microscope, 9x.

Since acceptance (about 1948) of *Anopheles earlei* Vargas as a northern species distinct from *A. occidentalis* D. & K., culicidologists have often assumed on larval morphological grounds (*earlei*—branched antepalmate hair 2 on abdominal segments IV and V; *occidentalis*—those hairs single) that the Alaskan anopheline is *A. earlei*. The egg of the Alaskan *Anopheles* has not been described. I have lately used *Anopheles* sp. even though aware the antepalmates are almost invariably multiple in Alaskan large larvae. I avoided use of *"earlei"* chiefly because the ova I collected from a pond near Chitina, Alaska and preserved, some in alcohol some in formalin, appeared entirely grey-brown, unbanded. It now seems likely that the Chitina eggs should have been examined fresh to reveal the color pattern. The purpose of this note is to acknowledge the morphological identity of Alaskan anophelines, at least from the coast of central Alaska, with *A. earlei* Vargas and to call attention for heuristic reasons to biological differences from Montana *earlei*.

Rozeboom (l.c.) suggests "that fundamental relationships between closely related species or subspecies are revealed more clearly through genetic and biological studies than through morphological comparisons." He showed that the multivoltine Montana form of *A. earlei* can be bred in the laboratory uninterruptedly generation after generation, that it will swarm and mate readily even in small cages simply upon insertion of the observer's hand, and that the female takes blood without protracted delay for an obligatory diapause. He considers the stenogamous behavior a specific character separating *earlei* from the morphologically similar *maculipennis* (type species) of Europe which requires a very large cage for swarming and mating.

Now, just such fundamental biological idiosyncrasies appear to separate Alaskan *earlei* from Montana *earlei*, including: (1) life cycle of the *Culiseta impatiens* type, i.e. single-broodedness with the female mating the season she emerges, engorging and ovipositing, however, only after hibernation nearly a year later; (2) courtship and mating eurygamous, requiring specific stimuli, still conjectural after two years' unsuccessful attempts at colonization. No mating took place in small cages or even in a large walk-in insectary under the stimulation of various arrangements of colored and white lights.

Hence, further biological studies like Dr. Rozeboom's work with Montana *earlei*, permitting comparison of Alaskan, Canadian, and United States populations of *A. earlei* with each other and with Siberian *A. maculipennis* might lead to more correct and significant names than the present ones.—William C. Frohne, Arctic Health Research Center, Public Health Service, Department of Health, Education, and Welfare, Anchorage, Alaska.

ASSOCIATION NEWS

SCHEDULE OF THE JOINT MEETING
AMERICAN MOSQUITO CONTROL ASSOCIATION
AND
FLORIDA ANTI-MOSQUITO ASSOCIATION

April 28–May 2, 1956

DiLido Hotel, Miami Beach, Florida

SUNDAY, APRIL 28

10:00 a.m.	Board Meeting, AMCA
4:00 p.m.	Registration

MONDAY, APRIL 29

9:00 a.m.	Registration
9.30	Welcoming
10:00–12:00	Invitational Papers
1:30–4:00 p.m.	Reports from Mosquito Control Associations and States
5:00	Business Meeting, FA-MA

TUESDAY, APRIL 30

9:00–10:45 a.m.	Symposium: Insecticides in Mosquito Control
10:45–12:00	Symposium: What Can Applied Ecology Contribute to Mosquito Control?
1:30–3:30 p.m.	Submitted Papers
3:30	Boat Trip
6:00	Hospitality Hour
8:00	Buffet Dinner

WEDNESDAY, MAY 1

9:00–10:30 a.m.	Submitted Papers
10:30–12:30	Symposium: Progress in Mosquito Control Through Elimination of Breeding Areas
1:30–3:30 p.m.	Submitted Papers
3:30–5:00	Business Meeting, AMCA
5:30	Fish Fry or Barbecue

THURSDAY, MAY 2

10:30 a.m.	Motorcade to Florida Keys or Excursion to Havana.

While plans are tentative at this time, subjects of the invitational papers are of a broad scope and world-wide interest including a report of the world-wide malaria eradication program, an evaluation of insect resistance to insecticides and its future significance on a world-wide basis, a report of the present status and future possibilities of biological control of mosquitoes, and a discussion of the importance of the relationship of taxonomy to mosquito control.

No formal evening sessions are scheduled.

Committee meetings will be announced and times arranged.

Local committees are arranging an entertainment program which may well surpass previous ones. Recall the traditional Fish Fries at Fort Pierce in 1948 and at Daytona Beach in 1953!!!

Before March 1, 1957:

1. Submit a title of your paper, an abstract, and an indication of the type of projector needed to Dr. Arthur W. Lindquist, USDA, Entomology Research Branch, Plant Industry Station, Beltsville, Maryland.
2. Make your plans for a pre-meeting or post-meeting visit to the laboratories of:

   Division of Entomology, Florida State Board of Health at Jacksonville;

   Section of Insects Affecting Man and Animals, USDA, at Orlando;

   Entomological Research Center, Florida State Board of Health at Vero Beach.

   Write to Mr. John A. Mulrennan, Bureau of Entomology, Florida State Board of Health, Jacksonville, Florida, who will assist with scheduling visits, arranging for transportation to Orlando or Vero Beach from Jacksonville to coincide with plane or train schedules on to Miami Beach.
3. Complete your plans to:

Attend the meetings
Make your reservations early
Come and enjoy Florida's warm hospitality
Arrange to visit the world-famous laboratories

—o—

Florida has what it takes to give
All who come even
More than they
Anticipate

Miami Beach—DiLido Hotel
April 28–May 2, 1956

NEWS AND NOTES

Dr. Jack Colvard Jones of the Laboratory of Tropical Diseases, N.I.H., Bethesda, Maryland, hastens to ask that we correct what he can only assume was an inadvertent error on our part in our little quotation about the toxicity of oxygen, which appeared in the September issue of News and Notes. He points out that mosquito larvae are able to withstand an hour in 100% oxygen, which is more than we can do. This certainly puts Man on the defensive in the question of which is the more enduring species, doesn't it? But probably few men fail to agree that we endure a heck of a lot more from mosquitoes than they ever have to from us, so far as that goes.

Mounting Rapidly from the Ridiculous to the Sublime, We Want to Mention that Dr. Stan Freeborn, whom most of us think of as primarily a mosquito man, but who is really the Provost of the University of California at Davis, was recently the subject of a full column by Will Connolly in, of all places, the San Francisco Chronicle Sporting Green. Connolly characterized Stan as "once dean of Imhoff septic tank research at Berkeley but since elevated to having a mosquito named after him," which settles once and for all, we guess, the old gag about the relative importance of sanitary engineers and entomologists. Connolly then went on to eulogize what Stan has done in making Davis not only a well-rounded University in its own right but also one where values have been kept normal. His special point was that Stan had managed to keep football an amateur sport at Davis, but he might have added that Stan's homely touch is equally manifested in his ability to mix high erudition with the necessary mud-slogging field work in teaching his hundreds of students who have gone forth to do mosquito control.

Bill Frohne Confesses He Is Going to Play Hooky from Alaskan Mosquito research for the next two years and work at the WHO Schistosomiasis Control Pilot Project in Leyte, Philippines, instead. The work there will deal with the limnology of the snail vector of the Oriental liver fluke. However, we hear that Bill will be encouraged to delve a little into local malaria problems as well; these may be changing as new areas are opened up to rice culture under the present malaria eradication project, which has heretofore dealt with stream breeders. Privately, Bill hopes especially to observe tropical swarms of male mosquitoes for comparison with Alaskan swarms, since, maybe, by so doing, he can sort out those swarming habits which pertain to extremes of arctic light and weather from those which belong to the natural history of mating mosquitoes generally. Anyhow, the Frohnes are mortgaging the future (they say) and taking along a jeep to permit them greater latitude in collecting plants and mosquitoes. A ten-cent air letter sheet addressed to Bill at the above-named Pilot Project, Palo, Leyte, Philippines, will reach him promptly, though he doesn't *say* how promptly he'll answer. We wish him well, and envy him the pleasure of being in the green and gracious Philippines for a spell.

As a Sort of "Pre-" Operational and Scientific Note, Bill Sends Us a Remark on Biting Snipe Flies which is very interesting and somewhat startling. "My correspondence leaves me in no doubt," he writes, "That folks of our sort are interested in these blood-sucking Symphoromyias, even in the States, and in bad spots here (in Alaska) every warm-blooded mammal seems to have to be. Anyhow, this year and last we broke through most of the bottleneck, found the larval habitats and got males of *S. atripes,* which nobody could catch since Osten-Sacken got *one* in 1876. I can't do justice to the subject now, but should make a comment to encourage others. *S. atripes* is abundant in spots high up in California. Provost Stan Freeborn and I have been corresponding about the problem at his mountain summer cottage." (This note will be followed by an article on the subject in an early issue.—Ed.)

The September-October Issue of "Skeeter," Organ of the Virginia Mosquito Control Association, contains a very useful discussion of the use of PDB in light-trap killing jars. This subject has been of increasing concern to many who feared the effect on children or inquisitive adults of the cyanide jars. "Skeeter" reports that the PDB killed the mosquitoes well and remained effective as long as enough material remained to cover the bottom of the jar. The furnishing of ventilation holes in the Dixie cup the whole distance up the sides as well as along the bottom proved to be essential to a good kill. "Skeeter" reported having the usual difficulty in killing large beetles, a difficulty which was solved in Georgia by the use of "beetle traps," an arrangement of insect pins to simulate a "tank trap," as reported in *Mosquito News* for December 1955, but felt that the results were encouraging.

In California, Mosquito Abatement Districts and Other Mosquito-Control Agencies have been increasingly drawn into the control, or attempted control, of other biting and non-biting Diptera. Chet Robinson reported from Alameda County that cooperative studies entered into with Parks Air Force Base for the control of Chironomids with chlordane wettable powder gave apparently satisfactory results. Similar cooperative

projects between mosquito abatement districts and Army and Navy installations against *Leptoconops* are getting under way and have inspired MO HIRST to write a jingle entitled, "NIPS":

A GNAT is just a little jigger.
In fact, he isn't any bigger
Than the point of a very small pin.
But the lump that he raises
Just itches like blazes
AND THAT'S WHERE THE RUB COMES IN!

L. R. BRUMBAUGH OF THE SAN JOAQUIN MOSQUITO ABATEMENT DISTRICT found weather conditions toward the end of summer ideal for mosquito breeding, and so he put his organization into high gear. In addition to treating 4,670 acres of infested water and some 3,150 catch basins and gutters, his men also called on 224 premises and found that 64 of them had back-yard type mosquito sources. Nineteen of the property owners immediately undertook to correct or eliminate these sources. A comparison of August's light trap catches with those of a year ago showed a reduction of approximately 30%. In about two more years, San Joaquin is going to have it licked, seems as if!

SINCE WE QUOTED THAT PECULIAR REMARK ABOUT STAN FREEBORN EARLIER IN THIS COLUMN maybe we'd better start off Who's Who by giving you the real lowdown on him. Stan was born in Hudson, Massachusetts and received his B.S. degree from the University of that State (it was then Massachusetts Agricultural College, of Fernald renown) in 1914. In 1924 he earned his degree of Doctor of Philosophy and in 1949 a Doctorate of Science from the same institution. His thorough grounding in mosquitoes, which started with Prof. W. B. Herms in 1914, is reflected in the methodical rise he made through all the stages of the faculty at the University of California. Beginning as an Instructor in 1914, he became Assistant Professor in 1918, Associate Professor in 1925, full Professor in 1932. He was named Assistant Dean at Berkeley and Assistant Director at Davis in 1937 and continued in this position with time out for Directorship of Operations as a Colonel in U.S.P.H.S. Malaria Control in War Areas during the years 1942 through 1945. In 1952 he was named Provost of the University of California at Davis which became transformed into a full-fledged University. His publications include "Mosquitoes of California," in 1926, and a re-issue with DR. R. M. BOHART in 1951; as well as others too numerous to list. The mosquito is, of course, *Anopheles freeborni*, the Western malaria vector.

ON THE EAST COAST WE HAVE A MYSTERY MAN WHO IS SELDOM THOUGHT OF AS BEING FROM HIS REAL STATE OF ORIGIN. Like Dr. Freeborn, this good Doctor rose steadily through the ranks to fame in a state considerably removed from that in which he was born. This birth was in Easley, South Carolina, in 1906, and our subject attended famed Clemson College, receiving his B.S. in 1929. He was a laboratory assistant at Ohio State from 1929 to 1931 while preparing for his Master's, which he received the latter year, after which he went to the New Jersey Experiment Station and received his Doctor's degree in 1934 from Rutgers. He was Assistant Entomologist of the Experiment Station from 1935 to 1942, Associate from 1942 to 1944 and Acting Chairman of the department from 1944 to 1945. (Beginning to catch on?) Meanwhile, back at the University, he had been Assistant Professor from 1940 to 1943 and Associate from 1943 to 1945. In 1945 he became the Chairman of the Department of Entomology of the Experiment Station and full Professor at the University. He is a long-time member of the Middlesex County Mosquito Extermination Commission, and of the New Jersey Mosquito Extermination Association, of which he has also been an officer. Married in 1937, Bailey has two sons who are now just the right age to keep him busy during the summer at the two hobbies he admits to: hunting and fishing. DR. BAILEY PEPPER, we mean.

ANOTHER WELL-KNOWN MEMBER WHO STUDIED AT RUTGERS IS RUSSELL W. GIES, who is now the Scientific Director and Executive Secretary of the Delaware County Mosquito Extermination Commission as well as Principal Sanitary Engineer for the Department of Health in the Commonwealth of Pennsylvania. Russell says he worked with many of the old timers, Dr. Julian B. Smith, Dr. Headlee, J. A. lePrince, Harvey R. Carter and many others, and claims to have been in mosquito control for 41 years and still enjoys "fighting the mosquitoes with the younger men." He must have started in mighty young to do all that, because there are many who can testify that he is still one of the "younger men"! Some folks just *keep their energy*.

E. CHESTER ROBINSON, the Manager of the Alameda County Mosquito Abatement District, was born in nearby Oakland, in 1901, and attended the University of California. He came into mosquito abatement in 1940, being for 15 years the manager of the East Side Mosquito Abatement District, which refers to the East Side of the San Joaquin Valley, before coming to his present position in 1955. He is a long-time member of the California Mosquito Control Association and our American Mosquito Control Association in both of which he has been an official. He says, wistfully, that his hobby is fishing, but keeping the District going at the pace Harold Gray set for it (which he has done, nobly) has given him little time to prove what his recreation would be if he had one. Better luck next year, Chet.

DONALD ROSS JOHNSON, WHOM WE MENTIONED IN SEPTEMBER AS RECRUITING ENTOMOLOGISTS FOR

OVERSEAS MOSQUITO CONTROL WITH F.O.A., was born in Chicago, Illinois on 9 February 1920 and received his B.S. degree from the University of Illinois in 1943. From that year through 1946, Don was O.I.C. of a Navy Malariology Unit (No. 72) in New Guinea and the Philippines. In 1946 he returned to this country and attended the University of Minnesota, where he received an M.S. in 1948, and then became Assistant State Entomologist until 1951. In that year the lure of the South Pacific, an old war-time infection, broke out in him and he suffered a slight relapse, going out to Indonesia for the U. S. Public Health Service, where he stayed until August of 1953. Since them, he has been in Washington, D. C., handling the far-flung affairs of those who have followed his example overseas in Southeast Asia and elsewhere. We guess Minnesota's lost him.

ART LINDQUIST AND BILL MCDUFFIE, WHO ARE HEAD AND ASSISTANT HEAD RESPECTIVELY OF THE DIVISION OF INSECTS AFFECTING MAN AND ANIMALS, ENTOMOLOGY RESEARCH BRANCH, USDA, and well-known to all of us, will conclude our Who's Who for this time.

ARTHUR W. LINDQUIST was born in Lindsborg, Kansas, in 1903 and graduated from Bethany College in that state, going from there to Kansas State College for a Master's degree. He became an entomologist with the then Bureau of Entomology and Plant Quarantine in Texas from 1931 to 1938 and in California from 1938 to 1941, being called then to join the famous and productive research team at Orlando, Florida, which did the basic research on DDT and has provided the military with a wide arsenal of methods. From 1946 to 1953 he was in charge of the field station at Corvallis, Oregon, and was then drafted to fill his present position. In that same year, his original Alma Mater awarded him a richly-deserved honorary degree of Doctor of Science. Beside his Department of Agriculture duties, Dr. Lindquist is a consultant on Scientific Research and Development for the Armed Services.

WILLIAM C. MCDUFFIE was born in Nettleton, Mississippi, on 25 January 1910 and graduated from Mississippi State College in 1931, later taking advanced work at the University of Florida. He started off badly, doing research on Pink Boll Worm in Texas and later research with the Division of Cereal and Forage Insects at Salt Lake City and Yuma, but he finally saw the light and began his work on insects affecting man and animals, and especially on mosquitoes, with George Bradley at New Smyrna Beach, Florida. He was a Major in the former Sanitary Corps of the Army and afterward came also to the Orlando Laboratory. Leaving to go to the laboratory at Kerrville, Texas, for two years, he soon returned to Orlando, where he was head of the laboratory until 1954, when he was sort of shanghai-ed to Washington.

AS A KIND OF FOOTNOTE TO WHO'S WHO WE WANT TO TELL YOU ABOUT ARCHIE HESS'S LOGAN FIELD STATION OF THE U.S.P.H.S. This Section of the Communicable Disease Center operates out of Logan, Utah, a pretty little city set in a very lovely valley, and their headquarters in an old-fashioned mansion-converted-to-laboratory is enough to make any investigator drool. Their investigations cover both plague and encephalitis, principally, and it is the encephalitis angle which we mosquito-fanciers are particularly interested in, of course. With the occasional occurrence of encephalitis in pretty nearly every corner of the country, none of us can be indifferent to this important research. But let's let Archie tell it: "The virus encephalitides are the most important mosquito-borne diseases in temperate North America. Epidemics, the larger of which occurred in the northern tier of the Central States in 1941 and those which occurred in California and Texas in 1952, continue to occur and are unpredictable. (The northeastern U. S. has recently learned that it is not excluded from this situation—Ed.) With the further expansion of irrigation farming in the West and a concomitant increase in mosquito vectors, there is every reason to expect that the encephalitides problem will become increasingly serious over more extensive areas."

In addition to studies on hosts of the virus and on vector bionomics, the Logan Station is conducting extensive research on vector prevention and control, in close coordination with other Federal, State and local governmental agencies and citizen groups and councils. Archie says of this, "The primary objective of this work is to develop techniques for 'building mosquitoes out' of projects during the period of planning and construction." This includes not only artificial water impoundments such as irrigation, ponds and sanitation projects, but also rivers and natural water resources, on some 100 of which the Logan Station reviewed and submitted vector control recommendations during the past year. Archie is assisted, we hardly need add, by a goodly number of eminent men and eminent A.M.C.A. members.

OUR FINAL WORD FOR THIS QUARTER MIGHT BE CALLED "WHERE'S WHERE" . . . where's *where who is,* that is. Ted Raley sends us a list, part of which we are giving below, of the members who have changed addresses in the last year. Ted thinks there must be something about mosquito workers which makes them nomads at heart, for we surely seem to move around more than is strictly explainable on general statistics. Some of the moving has been from one house to another, like BEN KEH'S which we mentioned a few issues ago. Some of the rest have been changes of job, geography and even genre, like that of DR. FRED BISHOPP, also noted heretofore. THE FOLLOWING

LIST IS BY NO MEANS COMPLETE so don't write in to ye Ed., please. He is not to blame. We'll amplify as much as we know how from time to time in future issues.

We mentioned last issue that CAPT. CARLYLE NIBLEY had left Atlanta (but not the Army) to do graduate work at the University of Maryland. His address is care of Dr. Bill Bickley, Acting Head, Department of Zoology. Other military changes during the year have been several. Among them: CARL W. BARTHOLOMAI is now Entomologist for the 3rd Army Area, Engineer Section, living at 3148 Lenox Rd., N.E., Atlanta, Ga., while DR. F. S. BLANTON, is also a refugee from Washington and is now at the Department of Entomology of the University of Florida, at Gainesville. CAPT. FRANK FAVORITE has also gone way down South to Dixie, and is also at Ft. McPherson (Atlanta) Georgia, at the 3rd Army Medical Laboratory, where he has been before. To balance the flow *from* Washington, we find CDR JOHN DECOURSEY, MSC, USN, who has come in to the Hub and is now at the Naval Medical School of the National Naval Medical Center, at Bethesda, Maryland. So, too, is LCDR ALAN C. PIPKIN, MSC, USN, who has left the West Coast for the same Naval Medical Research Institute, and DR. HARVEY I. SCUDDER, is not far away, having left Savannah, Georgia, for the National Institutes of Health, also in Bethesda, across the road.

The exodus from warm climes is further augmented by CAPT. GORDON FIELD, who has shed his uniform to return to the Department of Entomology of the University of Massachusetts, at Amherst, Mass. And some of our members have just completely up and left us, like DR. J. M. GINSBURG, who has left New Jersey for an assignment at Tel Aviv, Israel, where he may be addressed care of the American Embassy. (But see another note on Dr. Ginsburg). Then too, ELBERT B. DIXON, who didn't find it warm enough in Louisville, is now addressable at P. O. Box 372, Tampa, Florida. But JOHN B. DIMOND reverses all this trend by going from Ohio to the State of Maine Forest Service, in Augusta, Maine. And DR. STEPHEN M. K. HU, has now been for some months at the 406th Medical General Laboratory in Tokyo, the address being APO 343, San Francisco, California.

T. E. MCNEEL, whom we noted in June as going to Mexico City, has sent us his address, which is, Oficina Sanitaria Panamericana, Calle de Roma, Número 36B, Mexico D.F., Mexico. And DR. HAROLD TRAPIDO, whom we saw at the Northwestern International Conference on 1 September, in Salt Lake City, is now at the Virus Research Center, P.O. Box No. 11, Poona 1, India. He has promised us some notes from this very interesting-sounding assignment, and we hope he doesn't forget.

SOME WHO HAVE CHANGED LESS SPECTACULAR DISTANCES are TED AARONS, who is now at 1320 Third St., Berkeley 10, Calif.; HARVEY J. CRAWFORD, who has left Melbourne for P.O. Box 503, Eau Gallie, still in Florida; DR. D. G. DENNING now at 1684 Oak Park Blvd., Walnut Creek, California; HAROLD F. GRAY, whose address at Oroville is now Rt. 4, Box 4268, and ROBERT D. GRAY, who is now at 16781 Green St., Huntington Beach, Calif.

THE FOLLOWING ARTICLE FROM THE ENGINEERING NEWS RECORD of June 21, 1956 is of interest in that it represents another extension of mosquito control into an area which has long had a severe mosquito problem with very little attention being paid to it.

"Sanitary Engineers Will Be Hired to Combat Mosquitoes"

"North Carolina has just announced allocation of $57,400 from its contingency and emergency fund and plans for the appointment of three sanitary engineers. The engineers will be employed for a five-month period to combat an invasion of salt marsh mosquitoes on the coastal region.

"The situation in North Carolina is due in large part to a series of hurricanes which hit the state in 1954 and 1955, washing salt water over wide areas, and clogging drainage ditches and streams.

"Gov. Hodges said that $25,000 of the total will be used to match local funds on a 50–50 basis for insecticides and other supplies necessary for spraying the mosquitoes. Another $12,000 will be used to pay the salaries of three sanitary engineers for five months while they work at the job. And the remaining $25,000 will permit a Salt Marsh Mosquito Study Commission set up by the 1955 state legislature to continue its operations and make recommendations to the legislature when it convenes again in regular session next January."—T. D. Mulhern.

NO PLACE TO GROW. Lady's Choice Pickle Company of Hayward, California, has come up with a method of treating wooden tanks that saves the company money and reduces the headaches of mosquito control. Mr. C. H. McCoy of Lady's Choice, and Herb Brown, Division Foreman of the Alameda County Mosquito Abatement District, have been cooperating on mosquito control and have been striving to improve the tedious, repetitive spraying or fish planting. They have experimented with a number of methods, but feel they now have the best system yet tried.

The tanks are used in the production of pickles for about three to five months. During that time there is no problem of mosquito control because the brine is of sufficient concentration to discourage mosquitoes. It is the "off" period of seven to nine months that has caused the difficulties, for during that time the tanks were formerly filled with water to prevent shrinkage of the wooden staves, and they were an open invitation to mosquitoes and other annoyances. The method devised by McCoy and Brown eliminates

the standing water in the tanks during the "off" season. The vats are emptied, and shrinkage is prevented by routine sprayings with water, each two weeks. Sprinkling is accomplished by means of a sprinkler head commonly used in lawn underground sprinkler system, attached to a rubber hose. The springler is left in a tank just long enough to moisten the sides of the tank—about sixty minutes. It can be moved easily from tank to tank. The tanks are kept covered with loose 1" × 12" boards to keep them cooler and to reduce loss of water by evaporation.

Savings realized by the company are: reduced water bill; reduced cleaning time; less cleaning materials used; and less cost for sewer, which is metered. Each tank has a 6,000 gallon capacity, and there are 284 tanks. Mr. McCoy estimates the saving in water per tank under the new system is 12,000 gallons per year. 284 tanks times 12,000 gallons per tank means a total saving of water each year of approximately 3,408,000 gallons. At a cost of approximately fifty cents per 1,000 gallons of water for the supply, and six and six-tenths cents per 1,000 gallons of water for sewer, that means a saving of about $1,928.93 per year, in water alone.

When untreated water was placed in the tanks and allowed to stand, it quickly produced algae. These minute plants were an adulterant, and had to be removed by scrubbing the walls and floor of the tanks, an obviously time-consuming and expensive procedure. In the new system in which water is not allowed to stand in the tanks during the "off" season, algae are not produced.

Here is one of those fortunate circumstances in which all concerned are benefited by the product of a cooperative effort at solving mutual problems.—M. C. Kramer.

On October 5 we received the following contribution to "News and Notes":

"JOSEPH M. GINSBURG FROM RUTGERS UNIVERSITY is spending a year in Israel. He was appointed by the Research Foundation of the State University of New York to serve on Point IV program, sponsored by I.C.A. While on leave of absence from the University, he will be connected with the Israel Ministry of Agriculture and can be reached at: c/o U. S. Embassy, Agricultural Division, Tel Aviv, Israel."

As this issue of the "News" goes to press we have been informed that Dr. Ginsburg is now in Italy, and it is assumed that his plans will depend somewhat on the rapidly changing developments in the international situation in the Near East.

HARRY STAGE IS NOW BACK IN THIS COUNTRY, permanently, we hope, and his many friends in the East have enjoyed visiting with him during his comings and goings in the late summer and fall. On visits to relatives in Albany, New York, he called at the *Mosquito News* office, and we are happy to report that he is continuing his lively interest in *Mosquito News* and AMCA affairs, even though he has retired from official duties and is planning to make his home in Oregon. Mosquito control activities in the Northwest, which have increased of late, will undoubtedly profit by his presence there. Harry plans to attend the AMCA meetings in Miami Beach, and we will expect detailed reports on all his doings.—D. L. C.

DR. AND MRS. ROBERT GLASGOW left for the Philippine Islands in November to be gone for three or four months. Dr. Glasgow's many friends in AMCA who were aware of his interest in all things mechanical and his extensive practical knowledge in many different fields outside of entomology, should not be surprised to learn that he has been rendering distinguished service to the Philippines in their effort to rehabilitate their industry after its almost total destruction in World War II, and that one of the leading industrial concerns in the Islands is utilizing his services as a consultant.—D. L. C.

VIRGINIA MOSQUITO CONTROL ASSN.

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REVIEWS AND ABSTRACTS

THE JOINT ACTION OF DDT AND ETHYL ALCOHOL UPON ANOPHELINE LARVAE IN BIOASSAY SUSPENSIONS. By W. B. Hawkins, J. Econ. Ent. 49(4):433–435. 1956. 2 graphs, 2 refs. The toxicity of DDT dispersed in colloidal suspensions by the replacement of solvent method is correlated with the concentration of the initial DDT solvent in the suspension. The LD_{50} of *Anopheles quadrimaculatus* larvae in DDT suspensions containing 1.0, 0.1 and 0.01% ethyl alcohol increases by a factor of two with each tenfold decrease in alcohol concentration. However, there is no parallel increase in the LD_{90} when the percentage of alcohol decreases from 1.0 to 0.1, but the LD_{90} is doubled when the alcohol is further lowered to 0.01%. Test suspensions were prepared by dilution of aliquots of an initial suspension so that the alcohol concentration decreased parallel to the DDT concentration. As before, larval kill decreased with each lowering of the alcohol concentration, but to a greater degree, indicating the influence of other, but unknown factors. The toxic action of DDT is increased by conditioning the larvae in 2% alcohol solution prior to placing the larvae in DDT suspensions containing small amounts of alcohol. The results emphasize the necessity for studying this joint action of solvent and toxicant if with mosquito larvae more quantitative bioassay results are to be obtained.—Author's summary.

NOTES ON MICROCLIMATE AT THE SITES OF BREEDING AND BITING OF *Aedes* SPECIES (DIPTERA CULICIDAE) ON UKARA ISLAND, TANGANYIKA. By A. Smith. Proc. R. Ent. Soc. Lond., (A) 31(4–6):81–85. 1956. (1) Reflected light from a rock pool with *Aedes vittatus* larvae was of the order of 60 F. C. compared with 2 F. C. above a pool in a rot hole with larvae of *Ae. africanus, Ae. aegypti,* and *Ae. apicoargenteus* during the brightest parts of the day. Temperature varied 4.5° C. in the rock pool compared with 1° C. in a rot hole in a mango tree and 2° C. in a rot hole in a pollard. (2) Larger numbers of *Aedes* were caught on banana bait near foliage with a dark interior (2 F. C.) than near foliage with brighter interiors (20 F. C.) (3) Observations were made to study the biting activities of *Aedes* species in different natural surroundings. It was concluded that any advantageous differences of temperature, humidity or light at the position of the mosquito catchers were masked during daylight hours by the presence nearby of suitable thicket, which is a resting place for *Aedes*.—Author's summary.

(Note: Ukara Island is situated in Lake Victoria.)

THE ISOLATION OF ILHÉUS VIRUS FROM WILD CAUGHT FOREST MOSQUITOES IN TRINIDAD. By C. R. Anderson, T. H. G. Aitken, and W. G. Downs. Amer. J. trop. Med. Hyg. 5(4):621–625. 1956. 2 tables, 5 refs. Two strains of virus isolated in 1954 from forest mosquitoes in Trinidad, B.W.I., have been shown by reciprocal cross-neutralization tests to be strains of Ilhéus virus. Both strains produce a hemagglutinating antigen, similar in reactivity to the antigen produced from the known Ilhéus strain. These isolations represent the second and third times the virus has been found in nature.

Since submitting this paper for publication, four more Ilhéus virus isolations from Trinidad mosquitoes have been made by the laboratory. All isolations were made in 2-day-old mice inoculated with mosquitoes caught in the Rio Grande Forest about 8 miles northeast of Sangre Grande. Strain one (TRVL, specimen No. 10507) came from a mixed pool of 105 mosquitoes (21 species in 9 genera) collected December 16, 1955; strain two (TRVL, specimen No. 10554) came from a mixed pool of 233 mosquitoes (17 species in 8 genera) collected December 23, 1955; strain three (TRVL, specimen No. 10584) came from a mixed pool of 103 mosquitoes (13 species in 7 genera) collected January 3, 1956; and the fourth strain (TRVL, specimen No. 10654) was isolated from a pool of 7 *Psorophora ferox* collected January 10, 1956. All of the mixed pools contained reasonably large numbers of *Aedes* and *Psorophora* species except No. 10584 which had 30 *Aedes* (*serratus*) and only one *Psorophora* (*lutzi*).—Authors' summary and addendum.

NOTES ON *Anopheles marteri* SENEVET AND PRUNNELLE, 1927. By E. R. Shahgudian. Proc. R. Ent. Soc. Lond. (A) 31(4–6):71–75. 1955. 34 refs. 2 figs. (1) The examination and comparison of the larvae of *Anopheles marteri* Sen. & Prun. from Algeria with larvae of *A. marteri* var. *conquensis* from Spain has revealed no differences. The original descriptions of adults of *A. marteri* var. *conquensis* Torres Cañamares apply equally well to *A. marteri* from Algeria. There appears no necessity therefore to distinguish these forms on morphological grounds and it is proposed that the varietal name be sunk as a synonym.

(2) Larvae of *A. marteri* from Algeria, Tunisia, Spain, Transjordan, and Palestine are characterized by having shorter posterior clypeal hairs than those from Sardinia, Greece, Tadjikistan and Iran, and it is proposed that the first group should be regarded as typical of the species described by Senevet and Prunnelle and should retain the name *Anopheles marteri* subspecies *marteri*.

The forms occurring in the second group of countries are more nearly related to that described by Keshish'yan as *Anopheles sogdianus*,

and it is proposed that this group should therefore be named *Anopheles marteri* subspecies *sogdianus*.

(3) No constant morphological differences could be detected in other stages of these anophelines.—Author's conclusions.

Malaria Manual for U. S. Technical Cooperation Programs. Compiled by the Div. International Health, Public Health Service, Dept. Health, Education, and Welfare, Washington 25, D. C. Public Hlth. Tech. Ser. Manual I. Jan. 1956. 199 pp. This is the official basic malaria technical policy document of the International Cooperation Administration. The Manual is composed of 7 chapters and 18 attachments. In the Introduction are noted the incidence of malaria and its geographical distribution, the agencies of the world and of the United States which have been working on eradication and control, and the present status of the malaria and mosquito programs. At least 7 species of anophelines (*Anopheles gambiae, A. maculipennis, A. quadrimaculatus, A. sacharovi, A. stephensi, A. sundaicus,* and *A. superpictus*) "have been reported to have developed a physiological resistance to one or more of the chlorinated hydrocarbons."

Chapter II, 7 pages, summarizes: "A. Over-all Policy; B. Program Plans Review"; and "C. Relationship to Malaria Assistance by Other Agencies." Under "C" are discussed briefly ICA, WHO, and UNICEF, the principal agencies assisting national governments with malaria control or eradication programs.

"Operations," is the heading of the third chapter, which covers 21 pages. Subhead "A" includes: "1. Malariometric Surveys; 2. Entomologic Surveys"; and "3. Economic Surveys." Subhead "B" is "Planning of Operation Program," and it includes: "1. Insecticides; 2. Equipment; 3. Chemotherapy"; and 4. "Personnel." Under "1" is discussed the use of the insecticides, DDT and dieldrin, with dosages and preparations of the mixtures given in detail. Under "3" are listed the drugs, Pyrimethamins, Chloroquin, Primaquine, Proguanil, and Mepacrine, with schedules for suppressive and therapeutic treatments.

Chapter IV, "Research," occupies 2 pages; V, "Reporting," and VI, "Evaluation," are one page each; and VII, which is a list of the attachments, is 1½ pages. The 18 attachments, or appendices, occupy 160 pages, or ¾ of the entire Manual. These attachments include minutes of meetings; statements and policies set forth by committees and key organizations; specifications for recommended insecticides and a compression sprayer; examples of surveys and of forms to be used for various reports; an article by Dr. Fred L. Soper on, "Hemisphere-Wide Malaria Eradication," and one by Dr. G. Robert Coatney on, "The Present Status of the Anti-Malarial Drugs Chloroquine, Pyrimethamine (Daraprim), and Primaquine." The eighteenth attachment is a brief bibliography of suggested publications for malaria reference libraries.

Acknowledgment for assistance in preparation and review of the manuscript is given to Doctors Justin M. Andrews, George H. Bradley, G. Robert Coatney, Willard H. Wright, and Professor Everett D. Hawkins.

Although distribution of this Manual up to September was limited primarily to ICA field health staffs, a recent re-run has made available a few copies for qualified persons; and it is urged that only those interested in *international* malaria programs request copies. Those who do have this book on their shelves, will have access to a brief but well-written, clearly printed, authoritative document. Address Public Health Division, ICA, Washington 25, D. C.—H.L.T.D.

Transmission of Eastern Equine Encephalitis to Horses by *Aedes sollicitans* Mosquitoes. By W. D. Sudia, D. D. Stamm, R. W. Chamberlain, and R. E. Kissling. Amer. J. Trop. Med. Hyg. 5(5):802–808. 1956. 7 refs. *Aedes sollicitans* mosquitoes became infected with Eastern equine encephalitis (EEE) from feeding upon an inoculated horse. These mosquitoes, after 2 weeks' incubation, transmitted infection by bite to a normal horse. Attempts to infect more mosquitoes by permitting them to feed upon this second horse met with failure. The virus which circulated in the blood of the inoculated horse titered as high as $10^{-5.5}$, a level not commonly attained in horses. The horse infected by mosquito bite had a lower, more usual concentration of virus in the blood, inadequate to infect mosquitoes. The results of these studies prove it possible for an occasional horse to serve as an EEE infection source for mosquitoes. It is believed, however, that horses rarely play an important role in EEE propagation.—Authors' summary.

Selection of Larvae of *Anopheles quadrimaculatus* for Tolerance to DDT. By W. B. Hawkins. J. Econ. Ent. 49(4):567–569. 1956. 2 graphs, 3 refs. The dosage mortality data for the larvae of the Beaver Dam colony are plotted in Figure 1. It will be noted that there is some variation among the series of tests. The LD_{50}'s range from 0.0025 to 0.0038, while the LD_{90}'s range from 0.007 to 0.015 p.p.m. Except for the larvae of the F_1 generation of the BDR colony, those of the later generations show some increased tolerance of DDT (Fig. 2). A comparison of the data for the larvae of the BD colony and those of the F_5 generation of the BDR colony shows that 5 successive selections with DDT have increased the LD_{50} from 0.0025 to 0.0038 p.p.m. DDT to about 0.0076 p.p.m. DDT. By the same comparison the LD_{90} has increased from 0.007 to 0.015 p.p.m. DDT to about 0.025 p.p.m. DDT.

These increases in LD_{50}'s and LD_{90}'s of the BDR larvae have resulted not from a shifting of the curves throughout their length, but roughly

from a rotation about the 100 percent kill point such that the slopes of the curves have been increased. According to Hoskins and Gordon (1956) such increases in slope may only denote a greater vigor among the survivors of a selection. They also suggest that a population which responds to selection as have these *A. quadrimaculatus* probably lacks factors necessary for the development of true resistance. Thus, though conclusions must be drawn with restraint because of the small number of selective exposures, the data suggest that *A. quadrimaculatus* may be incapable of developing resistance to DDT.—Author's discussion.

(Note: Larvae taken from Beaver Dam, Kentucky, and maintained in the insectary at Wilson Dam, Alabama, are designated as the BD colony. The BDR colony is the one established by successive exposure of the larvae to DDT.)

THE VALUE OF MAXILLARY INDEX IN THE IDENTIFICATION OF MOSQUITO RACES. By M. A. R. Ansari and A. S. Nasir. Pakistan J. Health V(1):37–43. 1955. 16 refs., 3 figs. Some reliable information from elsewhere has been recently accumulated suggesting that behaviour of some anopheline mosquitoes considerably changes from place to place. A species notorious for its nefarious activities as a malaria vector at one place may be found innocent at another. The 2 forms showing different trophic responses exhibit no superficial morphological differences. A criterion to isolate these races has been felt a dire necessity and is partially found out.

Roubaud (1931) drew the attention of biologists to the importance of maxillary index in *Anopheles*. Trensz (1930) defined the maxillary index as the mean of the number of serrations in the female maxilla. Senior White (1937) stated that an increase in the number of maxillary teeth indicated zoophilism in mosquitoes. Races feeding constantly on domestic animals average 14–15 teeth, while those feeding on human blood have an index of 14 or less. Holstein (1954) applied this criterion to *A. gambiae* and was able to split this species into 2 distinct races. Campbell (1951) also had split *gambiae* into 2 groups on the same basis.

We studied the maxillary index of a random sample of *A. culicifacies* caught from villages around Lahore. The mean maxillary index was found to be 12.32. According to Holstein (loc. cit.), this collection is referable to paucidentate or anthropophilic group. The acid test to this conclusion is the precipitin test. Unfortunately we lack facilities for such a test; however, we have preserved the blood meals on filter papers and shall record the precipitin test when opportunity is available.—Adapted from authors' summary.

LA ERRADICACION DEL *Aedes aegypti* EN LAS AMERICAS. By O. P. Severo. Bol. Of. San. Pan 40(6):485–498. 1956. 4 figs., 14 refs. The first part of this paper presents a brief review of the measures developed to control the insect vectors of yellow fever and malaria, starting at the turn of the century with the confirmation of Finlay's theory on the role of the *Aedes aegypti* in yellow fever transmission and the definition by Ross and Grassi of the *Anopheles* role as malaria vector. Reference is made to the early campaigns by Gorgas in Havana and Oswaldo Cruz in Rio de Janeiro to combat these two mosquitoes by fumigation for the alate stage and mineral oil for the larval stage, together with the protection or destruction of containers. An account is given of how the control measures used also in other large port cities brought about the apparent disappearance of the disease in almost the entire Continent by 1908. Mention is made of what was done in the interval before yellow fever reappeared in Rio de Janeiro in 1928, when attention was drawn to certain epidemiological aspects of the disease leading Soper, in 1932 to the discovery of the sylvatic aspect of yellow fever, and showing that the solution of the problem lay in the eradication of the *Aedes aegypti*. It was demonstrated, in campaigns conducted in several South American countries under the auspices of the Rockefeller Foundation that eradication was possible with the use of technical and administrative measures based on systematic inspection of dwellings and compulsory application of petroleum to containers with foci.

Reference is made to the decisive phase of *Aedes aegypti* eradication in the Americas, which began with the advent of DDT and the turning over of responsibility for the problem to the Pan-American Sanitary Bureau in 1947.

A description is given of how the campaign was extended to almost all the countries and territories, with the aid and collaboration of the Bureau and contributions from TA/WHO, UNICEF, and IIAA. Stress is laid on the value of the technical standards adopted, which are based on the application of DDT by the perifocal method, and how these standards permitted the establishment of a criterion for proving eradication based on the residual action of DDT and on the biology of the *Aedes aegypti*, together with a periodic evaluation made of the results, the latter being considered generally, very satisfactory.

The second part of the paper comprises a summary of the progress of the campaign, describing the results obtained in the various countries and territories, as depicted in the map showing the areas considered to be free as well as those still infested. Also included is a table presenting the statistical data that served as the basis for the evaluation, together with two bar charts showing the development of the eradication campaign from 1948 to 1955 in the various countries and territories.—Author's summary.

RESIDUAL INSECTICIDAL SPRAYING IN SHEIKUPURA DISTRICT OF THE PUNJAB FROM 1951–1954 AND ITS RESULTS. Raft, S. M. and Rashid, A. Pakistan J. Health 5(2):88–95. 1 ref., 6 graphs,

5 tables. July 1955. The insecticidal spraying for 1951–1954 in the villages of Sheikhupura, one of the economically important districts of the Punjab, is discussed in this article. A spleen and parasite rate was determined for children between the ages of 2–10 years, before the start of operations in 1951; the spleen rate was 51.2 percent and the parasite rate was 43.4 percent.

Wettable DDT was prepared in the proportion of 1 lb. of DDT to 1 gallon of water, and 1 gallon was sprayed on 1,000 feet of surface with a deposit of 200 mgm. of DDT per square foot. The villages sprayed for the first time each year were given 200 mgm. per square foot, while those which were sprayed during the previous year were painted with 100 mgm. per square foot.

The tables and graphs indicate a gradual decrease in the spleen and parasite rate in sprayed villages, with a steady rise in the rates in the control areas. According to the figures, also, there was a decrease in the average number of fever cases as ascertained from door-to-door visits during November and December of each year. The number of cases ranged from 0.5 to 8.3 in the sprayed villages, and from 15.4 to 41.9 in the unsprayed villages. Blood films collected from infants born after the malaria transmission season indicate that malaria transmission was nil in the sprayed area, and ranged from 5.0 to 22.0 in the unsprayed area. There was also a marked decrease in the numbers of adult mosquitoes taken—0.9 to 2.5 in the sprayed area, and 3.1 to 13.3 in the unsprayed. *Anopheles* larvae per dip averaged from 1.0 to 3.5 in the sprayed villages, and 6.0 to 27.0 in the unsprayed ones.—H. L. T. D.

Mosquito Culture Techniques and Experimental Procedures. Helen Louise Trembley Durkee, Amer. Mosq. Control Assoc. Bull. No. 3:1–73, many refs. 1955. Helen Louise Trembley Durkee has condensed into most readable form an immense amount of information regarding the laboratory rearing of mosquitoes and safe techniques to use in handling them as vectors of disease. Based on her own years of experience in raising mosquitoes at the U. S. Department of Agriculture and the National Institutes of Health, her contacts with fellow researchers throughout the world, and a careful evaluation of the literature, she has written this excellent guide which should be of value to mosquito workers everywhere.

The main part of the Bulletin is 22 pages long, of which 13 pages are devoted to "Rearing," 6 pages to "Development and Behavior," 2 pages to "Disease Transmission," and 1 page to "Precautions." This is followed by a fine "Literature" section, 26 pages long, divided into four sections: Rearing, Development and Behavior, Disease Transmission, and General Reference Works, much of which is actually an annotated bibliography or a series of abstracts written by fellow research workers. There are abstracts here, for example, by Brookman and Reeves on the insectary rearing of *Culex tarsalis* and *stigmatosoma,* or by Chamberlain on *Culiseta melanura.* Finally there is a series of 17 figures or photographs showing model insectaries (with the author), rearing equipment, animal feeding cages, and various phases of laboratory work.

The main section devoted to "Rearing" gives detailed information about the raising of ten of the most commonly reared mosquitoes: *Anopheles quadrimaculatus, A. freeborni, A. aztecus, A. albimanus, A. stephensi, Aedes aegypti, Ae. albopictus, Ae. atropalpus, Culex pipiens,* and *Culex quinquefasciatus.* Here the reader will be impressed by her ability to discuss mosquito culture techniques in a most understandable and interesting manner and to make a critical evaluation of the numerous methods of raising mosquitoes recorded in the literature based on her own years of laboratory experience.

Many of the students from other countries who have studied at the Communicable Disease Center have expressed their appreciation of the clear style and wording and the excellent photographs in this fine bulletin. Since "Mosquito News" reaches so many workers outside the United States, either through subscriptions or the Good Neighbor Club of the American Mosquito Control Association, authors of future AMCA Bulletins should consider these aspects of publication which Helen Louise Trembley Durkee has achieved so very well.—Harry D. Pratt, Communicable Disease Center, Atlanta, Georgia.

PLEASE CORRECT

The cover of your copy of *Mosquito News* for September reads "Volume 16 . . . Number 2." It should read "Volume 16 . . . Number 3." We suggest you make this correction for convenience in future reference.

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